Section: Anatomy

Original Research Article

MORPHOLOGY AND PREVALENCE OF LUMBOSACRAL TRANSITIONAL VERTEBRAE IN SOUTH INDIA-A DESCRIPTIVE CROSS-SECTIONAL STUDY

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Abstract

Background: Lumbosacral transitional vertebra (LSTV) is a common congenital anomaly of the lumbosacral region, which includes sacralisation of the fifth lumbar vertebra and lumbarisation of a first sacral vertebra. This condition occurs due to a defect in the segmentation of the lumbosacral spine during development. The prevalence of this condition ranges between 4%-14% depending on various studies. The present study was conducted to estimate the proportion of specimens with Lumbosacral transitional vertebra and to describe the morphological features of specimens with Lumbosacral transitional vertebra in the Tamilnadu population. **Materials and Methods:** The descriptive cross-sectional study was conducted on 65 dried unbroken adult sacral vertebrae obtained from the osteology lab of Anatomy Department of Government Medical Colleges in Tamilnadu. The specimens were well examined, photographed and relevant anatomic features and measurements were recorded. **Results:** We have observed sacralisation in 5 specimens out of 65. So, the prevalence of specimens with LSTV was 7.7%. Complete sacralisation was observed in 4 specimens and incomplete sacralisation in 1 specimen. Morphological features regarding the level of synostosis, a fusion of body, laminae, articular process, transverse process, spinous process and types of each sacralised specimen were observed, and results were recorded. **Conclusion:** In some individuals, the lumbosacral transitional vertebra is also associated with disc herniation, sciatic pain and scoliosis. Failure to recognise the transitional vertebra during spinal surgery may cause serious complications.

INTRODUCTION

Lumbosacral transitional vertebra (LSTV) is the sacralisation of the fifth lumbar vertebra and lumbarisation of the first sacral vertebra, which occurs due to a defect in the segmentation of the lumbosacral spine during development.[1] It is a common congenital anomaly of a lumbosacral region, with the prevalence ranging between 4%-14% depending on various studies.[2,3] In sacralisation, usually, the L5 fuses partially or completely with the sacrum unilaterally or bilaterally. In lumbar sacralisation, L5 usually fuses with the sacrum. Very rarely, L4 and L5 fuse with the sacrum, unilaterally or bilaterally.+ Because of the sacralisation, L4 becomes the last lumbar vertebra and thereby loses the ability to perform like L5, leading to problems that include pain and discomfort in the low back. It leads to intervertebral foramen narrowing, followed by spinal nerve compression, which causes the pain. In L5 Sacralisation, intervertebral disc narrowing also occurs, which causes disc prolapse or degeneration.[4]

The primary causes of lumbosacral transitional vertebrae are improper formation and union of somites, which can cause vertebral abnormalities,

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including vertebral fusion, a cleft vertebra or hemivertebrae. A cranial shift means total or bilateral sacralisation of the last lumbar vertebra. Partial shift where there is a unilateral fusion of the transverse process. A caudal shift also results in the lumbarisation of the first sacral vertebra. The cranial shift is dominant over a caudal shift. Hence, sacralisation is more common than lumbarisation.[3] Studies in different regions show differences in morphological features. However, studies in South India remain scarce. So, this study focuses on the prevalence and morphological characteristics of lumbosacral transitional vertebra in the South Indian population.

The knowledge of its prevalence is essential for Anatomists from an academic point of view and also important for Clinicians, Surgeons and Radiologists for early diagnosis and surgical intervention. It is also very important for Radiologists while report X-rays, CT and MRI Scans for correct clinical and radiological assessment and for physicians to rule out secondary spinal disorders like disc herniation, disc degeneration, facet arthritis and radicular pains. The study aims to estimate the prevalence of specimens with Lumbosacral transitional vertebra and to describe the morphological features of specimens with Lumbosacral transitional vertebra.

MATERIALS AND METHODS

The descriptive cross-sectional study was conducted on 65 dried unbroken adult sacral vertebrae obtained from the Government Medical Colleges of Tamilnadu. The specimens were well examined, and the various morphological features were recorded. Out of 65 sacral vertebrae, vertebrae with normal morphological features are grouped separately, and Vertebrae with Lumbosacral transitional vertebrae are grouped separately.

Later groups were well examined for morphological features such as level of synostosis, a fusion of body, fusion of laminae, a fusion of articular process, a fusion of transverse process, and fusion of spinous process. Classifications were made based on the classification provided by Castellvi et al.[5]

Table 1: Classification of LSTV according to Castellvi et al.[5]

Type I	Dysplastic transverse process	Unilateral (a) or bilateral (b) large triangular transverse process, atleast 19 mm wide
Type II	Incomplete lumbarisation / sacralisation	An enlarged transverse process with unilateral (a) or bilateral (b) pseudarthrosis with the adjacent sacral ala
Type III	Complete lumbarisation / sacralisation	Enlarged transverse process, with unilateral (a) or bilateral (b) complete fusion with the adjacent sacral ala
Type IV	Mixed	Type IIa on one side and type IIIa on the other

RESULTS

We have observed sacralisation in 5 specimens out of 65. Complete sacralisation was observed in 4 specimens and incomplete sacralisation in 1specimen. So, the prevalence of specimens with LSTV was 7.7 %. Morphological features regarding synostosis, a fusion of body, laminae, articular process, transverse process, spinous process and types of each sacralised specimen are described in Table 2

Table 2: Table 2: Morphological features of lumbosacral transitional vertebrae

Figure	Level of synostosis	Body	Laminae	AP	TP	SP	Type
1	L5+S1+Rt SIJ fusion	Fused on the right side	Fused on the right side	Fused	Fused on the right side	Not fused	IIIa
2	L5+S1	Partially fused on both sides	Not fused	Fused	Fused on the right side	Not fused	IIIa
3	L4+L5+S1	Complete fusion	Fused on the right side	Fused	Fused	Not fused	IIIb
4	L3+L4+L5+S1+B/L SIJ Fusion	Complete fusion	Fused	Fused	Fused	Fused	IV
5	L4+L5+S1	Complete fusion	Fused	Fused	Fused on the left side	Not fused	II a

AP-Articular process, TP-Transverse process, SP-Spinous process, SIJ-Sacroiliacjoint

Figures 1-5: show the morphological features of lumbosacral transitional vertebrae on anterior and posterior views.

Figure 1: shows fused L5, S1 and right Sacroiliac joint. A- Anterior view showing fused body and transverse process on the right side and are separate on the left side. B- Posterior view of the same specimen shows fused lamina on the right side and fused transverse process on both sides, with separate spines.

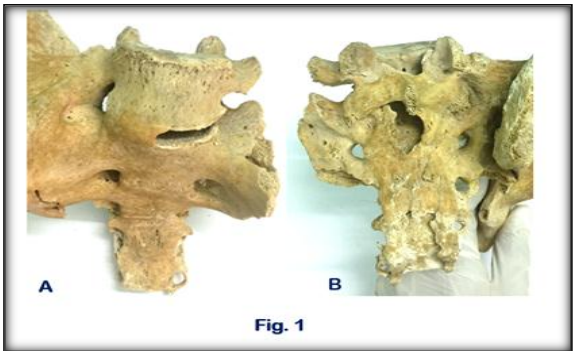

Figure 1:

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Figure 2: shows fused L5 and S1. A- Anterior view shows a partially fused body on both sides with narrow space at the centre and a fused transverse process on the right. B- Showing posterior view of the same specimen showing the fused articular process and separated laminae and spinous process.

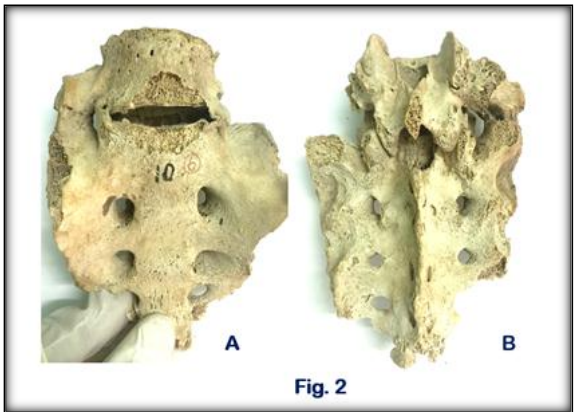

Figure 2:

Figure 3: shows the fusion of L4, L5 and S1. A- Anterior view showing completely fused body and transverse process. B- Posterior view showing fused lamina on the right side and fused transverse process on both sides and spines are not fused.

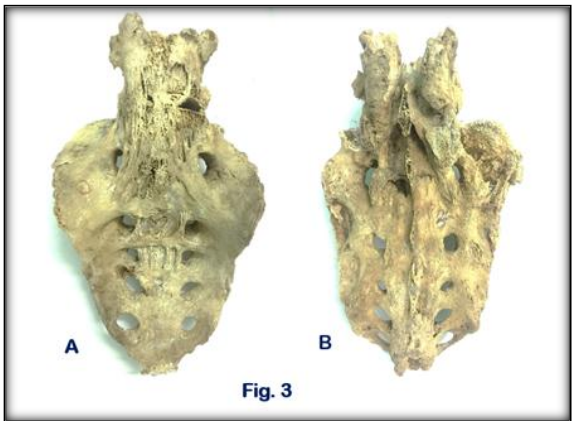

Figure 3:

Figure 4: shows fused L3, L4, L5, S1 and bilateral sacroiliac joints. A- Anterior view shows a completely fused body, a right transverse process, and pseudoarthrosis on the left side. B -Posterior view showing completely fused lamina, articular, and spinous processes on both sides.

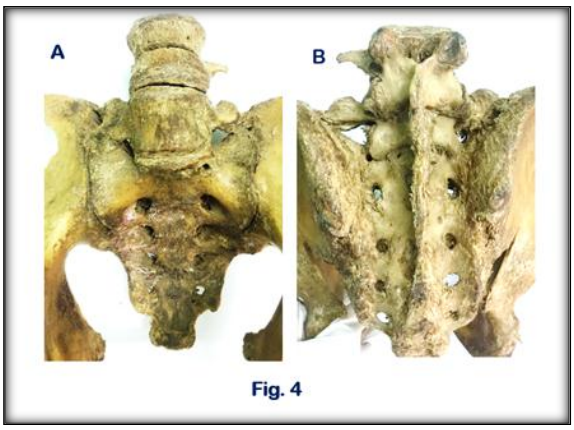

Figure 4:

Figure 5: shows fused L4,L5 and S1. A-Anterior view showing a completely fused body and pseudoarthrosis on the left transverse process and the right side not fused. B-Posterior view showing fused lamina and articular process, but spines are separate.

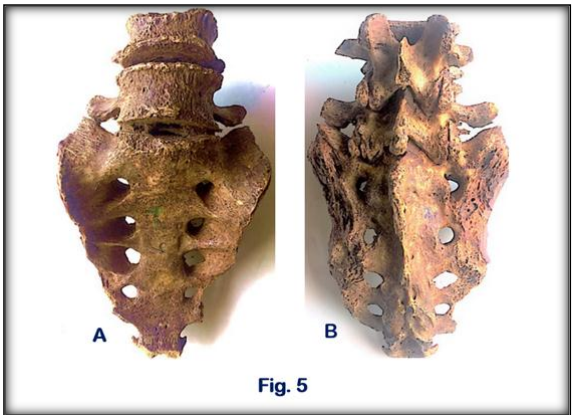

Figure 5:

DISCUSSION

Each vertebra passes successively through three stages of development: blastemal or membrane, cartilaginous and bony.[6] Sacralisation is related to the embryological development of the vertebra and sacrum. Segmentation of paraxial mesoderm starts to form somites on either side of the notochord along the craniocaudal axis during the 3rd week of intrauterine life. The vertebral column develops from somites which are derived from paraxial mesoderm. Each somite differentiates into a ventromedial part called sclerotome and a dorsolateral part called dermomyotome. The sclerotome is involved in the development of the vertebral column. The sclerotome cells become large, polymorphic and get loosely arranged to form embryonic tissue called mesenchyme. The mesenchymal cells can differentiate into fibroblast, chondroblast and osteoblasts. The mesenchymal cells from the sclerotomes migrate medially and condense around the notochord to form the centrum, around the neural tube to form right and left vertebral arches, and in the body wall adjacent to the proximal part of the vertebral part to form costal process.[7]

The adult derivatives of these structures are as follows: The centrum forms the vertebral body, the vertebral arches form pedicle, lamina, articular process and transverse process, and the costal

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processes form the costal element of the transverse process. The mesenchyme derived from each somite maintains its segmental character and can be seen as a distinct mesenchymal segment in the developing vertebral column.[7] Ossification of the vertebra begins in the 8th week and ends by the 25th year of life. There are three primary centres for each sacral vertebra, 1 for the body and 2 for each arch between the 10th to 20th weeks. Six primary centres for coastal elements of the upper three sacral vertebras appear in pairs, one on each side. Each vertebra has five secondary centres: one for the spinous process, one for the tip of each transverse process, and 2 for annular epiphysis. Thus, the sacrum has 21 primary and 14 secondary centres and completes ossification at 25. Ossification from 3 primary and 7 secondary centres occurs in lumbar vertebrae that fuse between 17 to 25 years of age. Any defect in these ossification centres leads to variant morphology of the vertebrae.[3]

Genetic predisposition and developmental influences are likely to cause sacral abnormalities. Wellik DM et al. showed that in the absence of Hox 11 function, sacral vertebrae are not formed; instead, these vertebrae assume a lumbar identity. Again, without Hox 10 function, no lumbar vertebrae are formed. Thus, these studies showed that the normal patterning of lumbar and sacral vertebrae as well as the changes in the axial pattern, such as Lumbosacral transition vertebrae, result from mutations in the Hox10 and Hox11 paralogous genes.[8] In 1917, Bertolotti was the first to describe an association between LSTV and Low back pain. Bertolotti described the relationship between low back pain and sacralisation of L5, known as Bertolotti syndrome. The possibility of Bertolotti syndrome should always be considered in young patients with low back pain.[9]

Kanchan T 2009 reported a case of unilateral lumbosacral transitional vertebra detected during a medicolegal examination of skeletal remains in a forested area. The congenital anomaly of the transitional vertebra helped identify the deceased.[10]

Chetan M et al. (2018) showed that sacralisation is a predisposing factor of lumbar degenerative changes in significant numbers in young patients with low back pain[1]Abbas Jet al. (2019) conducted a cross-sectional study on a population between 40-88 years age group to study the association between LSTV and degenerative lumbar spinal stenosis. They observed that LSTV was significantly associated with symptomatic DLSS.[11]

In 1984, Castellvi et al. proposed a classification (Table 2) for the transition degree based on the transverse processes form and orientation.[5]

In the present study, sacralisation was observed in 5 specimens. According to Castellvi classification, complete unilateral sacralisation was seen in 2 specimens (Fig- 1,2) which belong to type IIIa and complete bilateral sacralisation in 2 specimens (Fig- 3,4) which belong to IIIb and IV, respectively. Unilateral incomplete sacralisation was seen in 1 specimen (Fig 5), which belongs to type IIa. In addition, right sacroiliac joint fusion was seen in 1 specimen (Fig 1), and bilateral sacroiliac joint fusion in 1 specimen (Fig 4).

Table 3: Comparison of Prevalence of lumbosacral transitional vertebrae

Authors (years)	Population	No. of specimens	Prevalence
Sharma M 2013[3]	Punjab	48	10.42%
Deepa Somnath 2014 [12]	Puducherry	50	4%
Kumari S et al. 2016 [13]	Bihar	40	10%
Mamata sar et al. 2017 [14]	Odisha	15	13.3%
Patra A et al. 2018 [15]	Patiala	44	9%
Present study 2022	Tamilnadu	65	7.7%

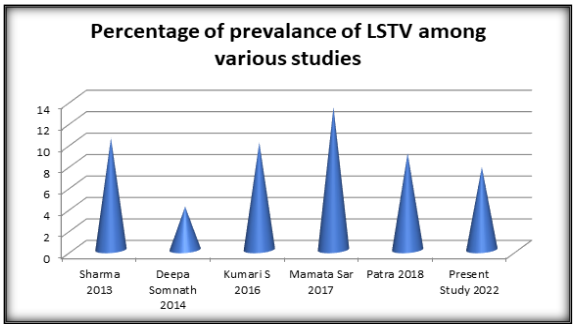

Chart 1: Comparison of prevalence of lumbosacral transitional vertebrae

Table 4: Comparison of types of lumbosacral transitional vertebrae

Authors	Type IIa	Type IIIa	Type IIIb	Type IV
Sharma 2013[3]			4	1
Deepa Somnath 2014[12]		1	1	
Kumari S et al. 2016 [13]			4	
Mamata sar et al. 2017[14]		1	1	
Patra A et al. 2018 [15]			2	2
Baruah Prabahita et al. 2018[16]			3	
Present study 2022	1	2	1	1

Prevalence of 7.7% in the present study of the Tamilnadu population. Type I and II were not seen in any studies. Type IIIb was commonly seen in all studies. Type IIIa is common in the present study.

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CONCLUSION

One of the ten individuals may be having sacralisation of a lumbar vertebra. Types observed in the present study are II a, IIIa, IIIb and IV. Among the four types, type IIIa is the most common in our study. In some individuals, the lumbosacral transitional vertebra is also associated with disc herniation, sciatic pain and scoliosis. Failure to recognise the transitional vertebra during spinal surgery may cause serious complications. Knowledge of sacralisation or lumbarisation is very important for orthopaedic and neurosurgeons operating in this region to avoid surgery at an incorrect level and also for anaesthetists during epidural, subdural and caudal anaesthesia administration.

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