

Morphological Study of Sacralisation of Fifth Lumbar Vertebra and Its Clinical Relevance

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Abstract

Background: The lumbosacral spine has an important role in spinal cord protection and maintaining the posture. Lumbosacral transitional vertebra (LSTV) is an anatomical variation of human spine. In LSTV, either the fifth lumbar vertebra may show assimilation with the sacrum (sacralisation), or the first sacral vertebra may show transition to a lumbar configuration (lumbarisation). **Objective:** The present study was conducted to determine the incidence of sacralisation on dry human adult sacra in North Maharashtra and to compare the findings with other studies. **Material and Methods:** The present study of sacralisation of fifth lumbar vertebra was carried out on 52 dry human adult sacra of known sex in the Department of Anatomy, ACPM Medical College, Dhule. This was an observational study over a period of six months from July 2016 to Dec 2016. The sacrum was examined to assess the sacralisation or lumbarisation and the findings were compared with other authors and correlated with Castellvi classification. **Result:** Sacralisation of fifth lumbar vertebra was noted in 4(7.7%) sacra and no lumbarisation of sacrum was found in our study. Out of 52 sacra, 40(76.9%) were male and 12(23.1%) were female. Complete sacralisation (50%) and incomplete sacralisation (50%) along with incomplete median crest was observed in the present study. **Conclusion:** Increased incidence of sacralisation may lead to increased chances of low back pain, disc herniation, pseudoarthrosis and compression of nerve roots. Hence knowledge of sacralisation is important for clinical anatomists, orthopedics, neurosurgeons, radiologists as well as anesthetists and physicians for diagnosing and operating the patients.

Keywords: Sacralisation; Lumbosacral Transitional Vertebra; Lumbarisation.

Introduction

The sacrum is large, triangular bone formed by five sacral vertebrae between the two hip bones.¹ It is also called as vertebra magnum. Normally there are five sacral vertebra between fifth lumbar vertebra cranially and first coccygeal vertebra caudally, forming four pair of sacral foramina [2]. Lumbosacral transitional vertebra (LSTV) are common congenital anatomical variation of the lumbosacral spine. Most frequently, fifth lumbar vertebra shows signs of

assimilation with the sacrum referred to as "Sacralisation" [3]. In case of lumbarisation, the first sacral vertebra show signs of transition to a lumbar configuration [4]. Being fused or semi-fused the L5 segment has more in common with its sacral neighbours than its lumbar one, so it is said to be sacralised [2].

In earlier studies various form and degree of sacralisation has been reported such as complete sacralisation consisting complete bony union between the anatomical transverse process and the sacrum. Incomplete sacralisation shows presence of a distinct joint line between the process and the sacrum. Both forms may be unilateral or bilateral. The frank sacralisation means sacrum shows 5 pairs of sacral foramina and 6 vertebral segments. Occult sacralisation means sacrum is high in pelvis and spinous processes of left vertebrae is above the iliac crests [5].

LSTV was observed for the first time by Bertolonni

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Received | 15.04.2017, Accepted | 24.04.2017

in 1917. This condition occurs due to defect in the sacralisation of the lumbosacral spine during development [6]. LSTV, an anatomical variation is observed in about 3.6% to 18% of the people and is usually bilateral [6]. Sacralisation may be either developmental, traumatic or age related which affect stability of the spine and its bio-mechanics becomes faulty over years [7]. Although this condition has an incidence of over 12% in general population, the knowledge about exact clinical implications is still lacking [3]. L5 sacralisation contributes to development of orthopedic diseases like low back pain, lumbar disc degeneration and herniation, degenerative spondylolisthesis, Bertollott's syndrome and difficulty in labour [8]. Failure to recognize such vertebral anomalies during spinal surgeries may pose serious complications.

The present study was undertaken to study the incidence of sacralisation on dry human sacra and to correlate with Castellvi classification.

Material and Methods

In the present study 52 dry human adult sacra of known sex available in the Department of Anatomy, ACPM Medical College Dhule were included. Damaged/broken sacra were excluded from the study. The type of study was observational study over a period of six months from July 2016 to December 2016. The sacra were observed by naked eye for any anatomical variation like sacralisation or lumbarisation, number of pelvic or dorsal sacral foramina, number of vertebral bodies and median crest. All the observations were noted and compared with other researchers. We tried to find out the most common type of LSTV in dry human adult sacra as per Castellvi et al [9] radiological classification.

Observation and Results

In the present study, 52 dry human adult sacra of both sexes were included, male sacra-40 (76.9%) outnumber the female ones- 12 (23.1%). We observed sacralisation of lumbar vertebra in 4 (7.7%) sacra. We noted complete sacralisation in 2 (50%) bones and remaining 2 (50%) bones showed incomplete sacralisation. In two sacra, there was a distinct residual space present between L5 and S1 (incomplete sacralisation) as seen in Figure 1 and 2, whereas 2 bones showed no space between them with complete fusion of L5 and S1 (complete sacralisation) as in Figure 3 and 4. The pelvic/anterior surfaces (Figure 1a, 2a, 3a, 4a) and dorsal/posterior surfaces (Figure 1b, 2b, 3b, 4b) of sacral bones showed 5 pairs of sacral foramina in between six vertebral bodies.

Incidence of sacralisation of fifth lumbar vertebra in the present study was 7.7%. The sacral hiatus and sacral cornue appeared to be normal in contour. In one of the dorsal aspect of sacrum (Figure 4b), we found incomplete median crest with non-fusion of the sacral vertebral lamina. Lumbarisation was not observed in present study.

Discussion

Lumbosacral transitional vertebra (LSTV) has characteristic two types of vertebra. In sacralisation of L5 the individual appears to have 4 lumbar vertebrae. Conversely, in lumbarisation there are six lumbar vertebrae. Sacralisation of 5th lumbar vertebrae is more common as compared to lumbarisation [10]. The incidence of sacralisation to lumbarisation was reported as 2:1 and this condition is more in males [11]. In the present study, we found sacralisation in 3 male sacra and single female sacrum out of 4 LSTV (7.7%) in 52 sacra (Table 1).

Table 1: Gender distribution of Sacralisation

Sacra	Male	Female	Total (%)
Normal	37	11	48(72.3%)
Sacralisation	03	01	04(7.7%)
Total	40	12	52(100%)

Table 2: Incidence of sacralisation of LSTV in different races^a

Race	Incidence (%)	Reference/Year
Australians	18	By Mitchell/1936
Indians	16	By Bustami/1989
Arabs	10	By Bustami/1989
Native of Britain	8.1	By Brailsford/1928
Americans	3.6	By Moore & Illinois/1925

Regarding incidence of LSTV, Castellvi et al [9] in 1983 reported an incidence of 1.7-14%. Based on literature, sacralisation varied from race and incidence in our study was 7.7% close to Native Of Britain (8.1%) as per Table 2.

The incidence of sacralisation ranges from 5 to 15% by previous studies done by Indian researchers. It was varied from place to place as shown in Table 3. In 2011, study by Sharma et al [12] showed incidence of sacralisation was 14.1 in central India, and Kubawat D et al [6] showed 11.1% in Gujarat (2012). In Western Maharashtra study (2013), 6.6% of sacralisation was noted as per Khairnar K et al [13]. Latest references from the available literature showed 5.3% of sacralisation on dry sacra in Tamil Nadu by Vasuki Manicka AK et al [14], 6% by Krishnamurthy A et al [2] in South Indian population and 14.3% in Madurai (2016) by Suman P et al [15]. Present study was in done in North Maharashtra (2016) and correlated well with Krishnamurthy A et al [2] and Khairnar K et al [13].

Embryologically, vertebrae are bi-segmental in development and each vertebra receives contribution from the caudal half of one sclerotome and cranial

half of succeeding one [2]. The outcome of LSTV may be linked to embryological development and defects in osteology. Sacralisation and lumbarisation are caused by the border shift, cranial shift and caudal shift to the segment which forms the part of vertebrae [16]. Apart from that shapes of the different vertebrae are regulated by HOX genes. The changes in the axial pattern such as LSTV result from mutation in the HOX-10 and HOX-11 paralogous genes [17]. Cranial shift are dominant over caudal shifts, hence sacralisation is more common than lumbarisation [12]. Ossification defects are other potential causes of variant morphology of vertebrae Like LSTV [12].

Radiologically, the AP and lateral lumbosacral radiographs with 30 degree angled cranially directed AP plain radiograph is the most accurate method of determining the LSTV. Castellvi et al [9] classified LSTV in type I to IV with correlation of radiographs and MRI as per Table 4. We tried to correlate this classification on dry sacra in our study. In present study of sacralisation, we found type IIIb (bilateral complete fusion of transverse process with adjacent sacra ala) was the most common type and same was correlated with Suman P et al [15].

Table 3: Incidence of sacralisation from Indian authors in different regions

Indian authors	Incidence (%)	Place/Year
Sharma et al ¹²	14.1	Central India/2011
Kubawat D et al ⁶	11.1	Gujarat/2012
Khairnar K et al ¹³	6.6	Western Maharashtra/2013
Vasuki Manicka AK et al ¹⁴	5.3	Tamil Nadu/2016
Suman P et al ¹⁵	14.3	Madurai/2016
Krishnamurthy A et al ²	6	South India/2016
Present study	7.7	North Maharashtra/2016

Table 4: Classification of LSTV according to Castellvi et al [9]

Type I	Dysplastic transverse process	Unilateral(a) or bilateral(b) large triangular transverse process at least 19mm wide
Type II	Incomplete sacralisation/lumbrisation	Enlarged transverse process with unilateral(a) or bilateral(b) pseudoarthrosis with adjacent sacral ala
Type III	Complete sacralisation/lumbrisation	Enlarged transverse process, with unilateral(a) or bilateral(b) complete fusion with adjacent sacral ala
Type IV	Mixed	Type IIA on one side and Type IIIa on the other



Fig. 1a: (Pelvic/anterior surface of sacrum showing 5 pairs of sacral foramina with incomplete fusion of L5 and S1 vertebral bodies with distinct space between them.



Fig. 1b: Dorsal/posterior surface of sacrum showing 5 pairs of sacral foramina and incomplete fusion of lamina between L5 and S1



Fig. 2a: Pelvic/anterior surface of sacrum showing 5 pairs of sacral foramina with incomplete fusion of L5 and S1 vertebral bodies with distinct space between them.



Fig. 2b: (Dorsal/posterior surface of sacrum showing 5 pairs of sacral foramina and incomplete fusion of lamina between L5 and S1)

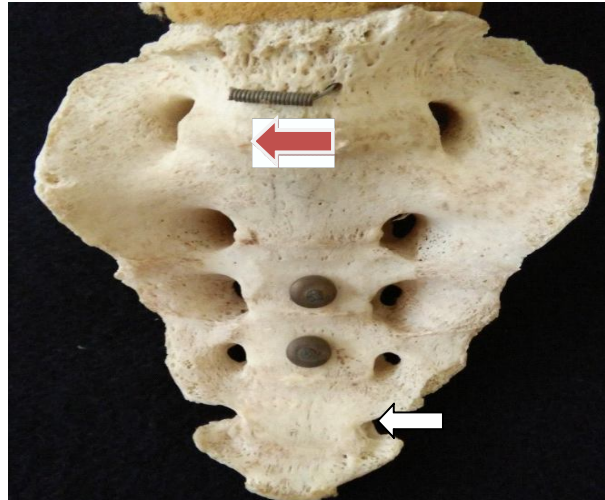


Fig. 3a: Pelvic/anterior surface of sacrum showing 5 pairs of foramina (white arrow in 3a) between 6 vertebral bodies with complete fusion of L5 and S1 vertebra (brown arrow in 3a) without any space in between them.

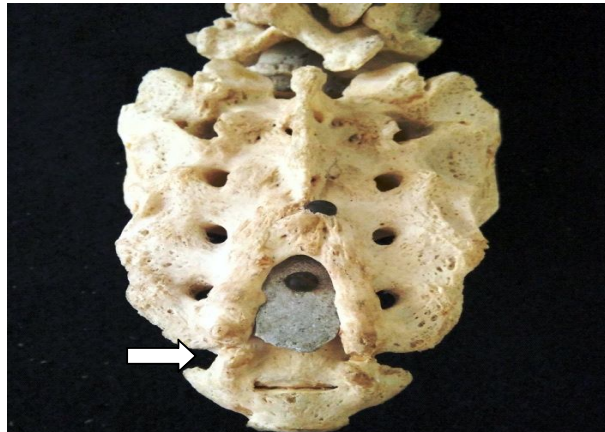


Fig. 3b: Dorsal/posterior surface of sacrum showing 5 pairs of sacral foramina (white arrow) and complete fusion of lamina between L5 and S1.



Fig. 4a: Pelvic/anterior surface of sacrum showing 5 pairs of foramina between 6 vertebral bodies with complete fusion of L5 and S1 vertebra without any space in between them.



Fig. 4b: Dorsal/posterior surface of sacrum showing 5 pairs of sacral foramina and incomplete median crest with non-fusion of sacral lamina.

Applied Anatomy

The association of LSTV and low back pain is known as Bertollott's syndrome. Low back pain in LSTV was first described by Bertollott, almost a century ago and has been debated issue [3]. The patients with LSTV are often suggested to be prone to various secondary pathologic spinal conditions like intervertebral disc degeneration or and herniation, facet joint arthrosis and spinal canal or foramina stenosis [3]. Over the years, LSTV may give rise to pain due to compression of nerve trunks, ligament strain/pseudoarthrosis of the anomalous joint [2]. The sacralised vertebra alters the biomechanics of lumbar spine and give rise to limited motion between L5 and sacrum due to anomalous articulation and bony fusion. Later on it leads to arthritis, disc changes and spinal cord compression [2]. Sacralisation of the fifth lumbar vertebrae may cause greater difficulty during labour because of less mobile pelvis and may cause back pain [6].

Sacralisation thus demands vigilance and modifications during anesthetic and surgical intervention. Knowledge of LSTV is important for orthopedics and neuro-surgeons operating in this region to avoid surgery at incorrect level and for anesthetists during administration of intradural and epidural anesthesia [2]. It is important to know about LSTV for radiologists while operating CT, MRI and X-Ray for correct clinical and radiological assessment. Physicians should be aware of sacralisation to rule out pathological spinal disorders like arthritis, disc degeneration and herniation [2].

Conclusion

Accurate identification of sacralisation can help to avoid complication in treating the patients in routine practice. The sacralisation of fifth lumbar vertebrae from the time of its development deserves attention of clinical anatomists, orthopedic surgeons, obstetricians, radiologists, neurosurgeons, anesthetists, physiotherapists and forensic experts. The present study highlights the incidence of sacralisation and its clinical relevance in day to day routine practice.

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