OESTEOGENIC STUDY OF LUMBOSACRAL TRANSITIONAL VERTEBRA IN CENTRAL INDIA REGION

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ABSTRACT

The morphological variations in the lumbosacral region are accidental findings during the study of dry human sacra. Most easily identified and detectable anatomical variations are related with change in the number of sacral vertebra by union of fifth lumbar vertebra or first coccyx and deletion of first sacral vertebra. These variations may be found in the living during radiological investigations for pain and neurological symptoms of patients.

The study was designed to know the prevalence of Lumbosacral Transitional Vertebra in Central India as there is paucity of available literature. Considering the variations, we conduct this study as a prelude to any type of experimental work in biomechanics, for diagnostic and therapeutic purposes in low back pain and for interventional procedures like spinal anesthesia and lumbar puncture.

Setting & Design: Observational study was carried out on 206 dry sacra including human skeletons obtained from Department of Anatomy and Forensic Medicine & Regional Medicolegal Institute of Bhopal & Raipur.

Morphometric measurements of 168 normal and 38 lumbosacral transitional vertebras were recorded and classified as per Castellvi's classification. Sacra showing fusion of coccyx were also included. All the parameters of variant sacra were compared with normal sacra.

38 (18.4%) lumbosacral transitional vertebra of which 29 (14.1%) cases of sacralization, 9 (4.3%) cases of lumbarization and 16 (7.8%) cases of fusion of coccyx were found. 14(36.8%), 5(13.2%), 17(44.7%) and 2(5.3%) sacra falls in type I, type II, type III and type IV of Castellvi's classification.

Lumbosacral transitional vertebra is attributed to its embryological origin. These variations is outcome of series of morphological changes during the transition and may interfere with the normal functioning because of compression of nerves, soft tissue and ligamentous strain between joints. Knowledge of these variations have become increasing important because of increased incidence of lower back pain, sciatica, disc prolapsed and in interventional procedures like spinal anesthesia and lumbar puncture.

Key Words: Sacrum, lumbosacral transitional vertebra (LSTV), Sacralization, lumbarization, transverse process

INTRODUCTION

The Lumbosacral spine is important as it protects the spinal cord and spinal nerves, Supports and transmits weight of the body to the lower limbs and thus plays an important role in posture and locomotion. Normally, lumbar vertebra are characterized by a large, kidney shaped body, transverse processes, stout pedicles and lamina, short, thick, square spinous process, transversely curved articular facets. The fifth lumbar vertebra have a wide curved inferior articular processes, large angled pedicles with transverse processes projecting from the entire length of the pedicle and large vertebral body.[1,2] Adult human sacrum is a wedge shaped bone with its base uppermost and formed by fusion of five sacral vertebra below the lumbar region. Its superior wide base articulates with fifth lumbar vertebra at lumbosacral angle and its blunted caudal apex articulates with coccyx. The anterior projecting edge of body of first sacral vertebra is sacral promontory. It has four pair of pelvic sacral foramina which communicates with sacral canal. On convex dorsal surface have median sacral crest with three or four spinous tubercles representing fused sacral spines. Coccyx is a small triangular bone formed by fusion of four rudimentary coccygeal vertebras. Body of last sacral vertebra articulates with body of first coccygeal vertebra and coccygeal cornua articulate with sacral cornua.[1,2] It is expected that any sort of compromise in these skeletal features by any pathology, either congenital or acquired, will affect the stability of the spine and its biomechanics.[3,4,5] Developmental

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defects occurring at the lumbosacral border results in transitional vertebra with mixture of lumbar and sacral characteristics. The morphology of affected vertebra is intermediary or transitional with a combination of lumbar and sacral anatomical structures resulting into variety of anatomical configurations collectively called as Lumbosacral transitional vertebra (LSTV).(3) Sacralization refers to condition where the last lumbar vertebra acquires sacral characteristics and articulates with sacrum. Lumbarization refers to a condition where the first sacral segment acquires characteristics of the lumbar vertebra. Inclusion of coccyx refers to fusion of coccyx vertebra with last sacral vertebra. [2,3,4]

The prevalence rate of LSTV varies from 4% to 35.9% based on diagnostic criteria, imaging techniques and on the clinical presentation of the patients. On the basis of the systematic review of comparable studies, the prevalence rate of lumbarization varies from 3.4% to 7.2% while sacralization varies from 1.7% to 14%. [5,6,7,8,9,10]

According to Castellvi's classification, there are four types of lumbosacral transitional vertebrae on the basis of morphological characteristics. Type I includes dysplastic transverse process with width more than 19 mm unilateral (a) or bilateral (b), Type II includes incomplete lumbarization/sacralization with enlarged transverse process unilateral (a) or bilateral (b) and pseudoarthrosis with the adjacent sacral ala, Type III includes complete lumbarization/sacralization with complete fusion of the transverse process of fifth lumbar vertebra to the sacral ala, unilateral (a) and bilateral (b). Type IV includes mixed variety of type IIa on one side and type IIIa on the other.[6]

The association of lumbosacral transitional vertebra and low back pain is known as Bertolotti's syndrome. "Bertolotti's syndrome" is characterized by the presence of a variation of the fifth lumbar vertebra having a large transverse process, either articulated or fused with the sacral base or iliac crest, and producing a chronic, persistent low back pain.[6,9,11] Bertolotti (1917) stated that these abnormal vertebrae may produce low back pain due to arthritic changes occurring at the site of pseudoarthrosis.[11] Some authors believe that the lumbosacral transitional vertebra could cause symptoms of back pain and or sciatica,[10,11,12,13] while others believe that this abnormal vertebra does not affect the incidence of lower back pain.[7,14,15]

The prevalence of LSTV and its various types vary in different populations under study.[16] So, LSTV become important for anthropological implications, bioarchiological studies and medicolegal identification. Clinically, the incidence of backache is increasing and its correlation to lumbosacral transitional vertebra is important. As the lower back pain is resultant of the activity in real life dynamic situations, understanding of the morphological changes in the lumbo-sacral transitional vertebra will provide a base to biomechanical studies. This study is to know the prevalence of Lumbosacral Transitional Vertebra in Central Region of India and to categorize LSTV with clinically applicable standard classification system that will help to understand the series of morphological changes during lumbosacral transition that in turns help in diagnostic and therapeutic management of illness around lumbosacral region.

MATERIAL AND METHODS

In this study 206 dry human sacra including 32 human skeleton (n= 206) were studied from the Department of Anatomy, Forensic Medicine and Regional Medicolegal Institute, G.M.C. Bhopal(M.P.) and Pt. J.N.M.M.C Raipur (C.G.).

Lumbosacral transitional vertebra is classified as per Castellvi's classification.[6] Dry human sacra and human skeleton were studied for lumbosacral transition and numerical variations. The Morphometric measurements of all the sacra and fifth lumbar vertebra were recorded by using slidin calipers, thread and scale. Straight length, curve length, width at base of sacrum, transverse and anterio-posterior diameter of body and ala, length and width of transverse process of fifth lumbar vertebra, shape of sacral hiatus, location of apex and base and height of sacral hiatus were recorded in both normal and variant vertebra. Skeletal variations like Sacralization of L-5, lumbarization of S-1, number of sacral vertebr, shape of sacral hiatus and coccygeal fusion were also recorded.

OBSERVATIONS

In present study of 206 dry human sacra 124(60.2%) were male and 82 (39.8%) were female sacra. 38 cases (18.4%) of lumbosacral transitional vertebra and 168 (81.6%) normal vertebra were found including sacra of coccygeal fusion. Out of these 124 male sacra, 26(21%) cases and out of 82 female sacra, 12 (14.6%) cases of lumbosacral vertebra were found. During our study, we found 38 (18.4%)

Types	No. of Sacra	Male	Female
Lumbosacral Transitional Vertebrae	38 (18.4%)	26 (21%)	12 (14.6%)
Normal Lumbosacral vertebra	168 (81.6%)	98 (79%)	70 (85.4%)
Total	206	124 (60.2%)	82 (39.8%)

Table 1- Prevalence of Lumbosacral Transitional Vertebrae

Sex	Type I			Type II			Type III			Type IV
	UL(Ia)	BL(Ib)	Total	UL(IIa)	BL(IIb)	Total	UL(IIIa)	BL(IIIb)	Total	
Male	4 (44.4%)	5 (55.6%)	9 (64.3%)	3 (75.0%)	1 (25.0%)	4 (80.0%)	4 (36.4%)	7 (63.6%)	11 (64.7%)	2 (100%)
Female	1 (20%)	4 (80%)	5 (35.7%)	1 (100%)	0	1 (20%)	2 (33.3%)	4 (66.7%)	6 (35.3%)	0
Total	5/14 (35.7%)	9/14 (64.3%)	14/38 (36.8%)	4/5 (80%)	1/5 (20%)	5/38 (13.2%)	6/17 (35.3%)	11/17 (64.7%)	17/38 (44.7%)	2/38 (5.3%)

Table 2:- Classification of Lumbosacral transitional vertebra (UL-Unilateral, BL-Bilateral)

Types	MALE	FEMALE	TOTAL
Sacralization	20(69%)	9(31%)	29(14.1%)
Lumbarization	6(66.7%)	3(33.3%)	9(4.3%)
Total	26(68.4%)	12(31.6%)	38(18.4)
Coccyx fusion	9(56.2%)	7(43.8%)	16(7.8%)

Table 3: Prevalence of lumbarization, sacralization & fusion of coccyx in cases with lumbosacral transitional vertebrae

Name of observer	No. of Cases	Transitional Vertebra	Lumberisation	Sacralisation
Mohoto (2010)[25]	332	42 (12%)	-	-
Hughes et al (2006)[15]	500	67 (13.4%)	21(4.2%)	46 (9.2%)
Delport et al (2006)[26]	300	90 (30%)	-	-
Dai et al (1999)[27]	460	126 (27.4%)	-	-
Peh et al (1999)[28]	129	17 (13.2%)	9 (7.0%)	8 (6.2%)
Vergauwen et al (1997)[7]	350	53 (15.0%)	-	-
Hald et al (1995)[20]	5781	792 (13.7%)	341 (5.9%)	451 (7.8%)
Hahn et al (1992)[29]	200	24 (12%)	9 (4.5%)	15 (7.5%)
Castellvi et al (1984)[6]	200	60 (30%)	-	-
Present study	206	38 (18.4%)	9(4.3%)	29 (14.1%)

Table 4 Comparison of Prevalence of Lumbosacral Transitional Vertebra with earlier observers

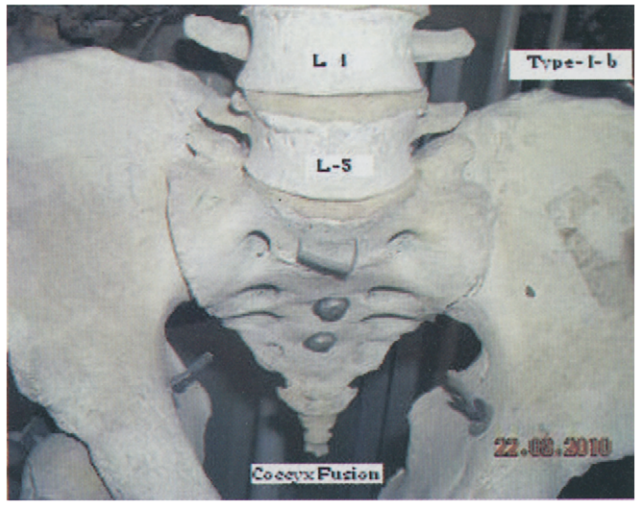

Fig. 1: Type I b- Lumbosacral transitional vertebra Enlarged dysplastic transverse process of 5th lumbar vertebra on both sides with width 33 mm and tip of transverse process reach upto the auricular surface of ileum.

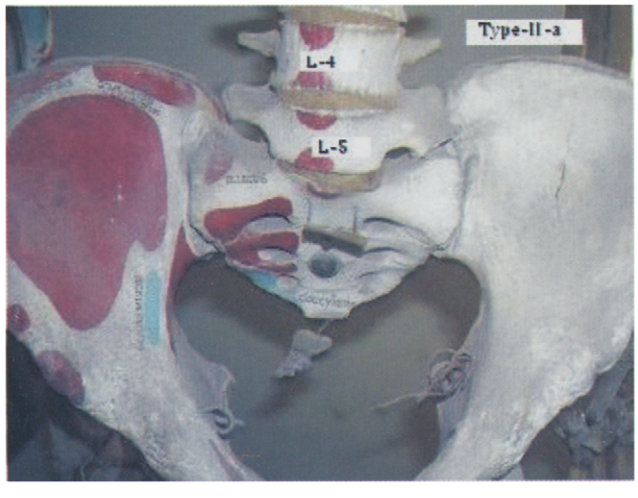

Fig. 2 - Type II-a Lumbosacral transitional vertebra Dysplastic transverse process of 5th lumbar vertebra on both sides. On left side transverse process was measured 31 mm with diarthrodial joint between transverse process of 5th lumbar and sacrum & auricular surface of ileum. On right side, dysplastic transverse process measured 29mm and reach upto auricular surface of ileum.

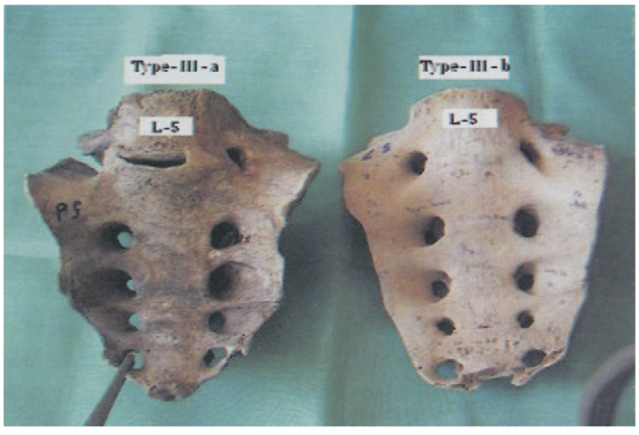

Fig. 3- Type III a & Type III b Lumbosacral transitional vertebra Dysplastic transverse process of right and left side of lumbar vertebra measured 29 mm and 26 mm. The transverse process on left side of lumbar vertebra is enlarged and completely fused with the ala of sacrum. (type III a). Transverse process of both sides shows complete osseous fusion with the ala of sacrum. (Type-III-b)

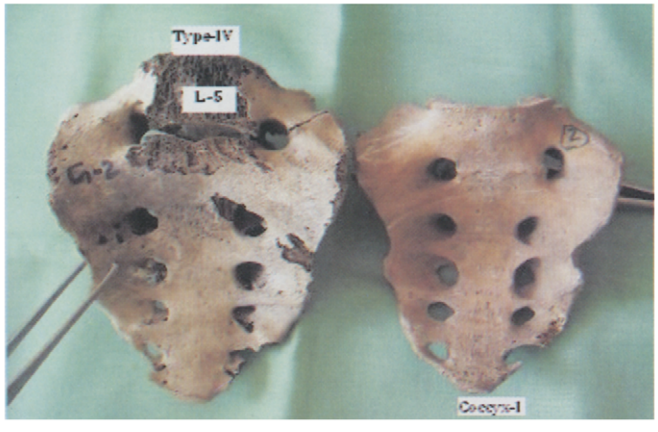

Fig. 4 - Type IV L.S.T.V. & Fusion of coccyx Transverse process on right side is completely fused, on left side it shows well defined joint line between body of lumbar vertebra and body of sacrum and inferior articular facet shows well defined joint line. (type IV, mixed type)

cases of LSTV of which 9(4.3%) were of Lumbarization and 29 (14.1%) were of sacralization and 16 (7.8%) were cases of fusion of coccyx. 16 cases of fusion of first coccygeal vertebra with the sacrum were observed, of which 5(31.3%) cases showed complete fusion of body and sacral carnua with coccygeal carnua. In 11(68.7%) cases body is fused but carnua shows incomplete osseous fusion. There was a greater tendency towards the reduction of length of vertebral column. Therefore the incidence of sacralization is higher than lumbarization.

Out of total 38 cases of the lumbosacral transitional vertebra, 14 (36.8%) cases fall in Type- I of Castellvi's classification out of which 5(35.7%) were unilateral and 9(64.3%) were bilateral. 5(13.2%) cases fall in Type II of Castellvi's classification out of which 4(80%) were unilateral and 1(20%) bilateral. 17(44.7%) cases fall in Type III of Castellvi's classification out of which 6(35.3%) were unilateral and 11(64.7%) were bilateral and 2 (5.3%)cases fall in Type IV category of Castellvi's classification.

Out of 38, 15(39.5%) sacra showed unilateral changes of which 5(33.3%) were in Type-I, 4 (26.7%) in Type-II and 6 (40%) in Type-III. 23(60.5%) sacra showed bilateral changes that includes 9(39.2%) in Type-I, 1(4.3%) in Type-II, 11(47.8%) in Type-III and 2(8.7%) were in Type IV category.

Other skeletal variation observed during the study includes defect in dorsal wall of sacrum in 8 cases of which 5(62.5%) were partial and 3(37.5%) were complete. Rare deformities like fusion of sacrum with right hip bone in 1 case and fusion of L-4, 5 and sacrum in 1 case were also observed. In one skeleton we have found in one case lumbosacral transitional vertebra type 3(a) associated with cervical rib, such co-occurrence is also mentioned in literature. [5,15]

DISSCUSSION

The prevalence of a lumbosacral transitional vertebra varies greatly in general population, ranging from 4% to 35%.[6,7,8,9,10] Our study shows that the prevalence of LSTV is 18.4%. Our finding is comparative with the prevalence reported by other observers. (Tab.-5) The prevalence of the lumbosacral transitional vertebra also varies in different populations by origin. Hsieh et al (2000), Erken et al (20 2), Mitchell (1936), Bustami (1989) and Brailsford (1 28) reported prevalence of LSTV to be 4%, 35.9%, 18%, 16% and 8.1% in Chinese, Turkish, Australian, Indian and British population respectively.[9,17,18,19] Our study shows prevalence of LSTV to be 18.4% in central Indian population.

In present study, the prevalence of sacralization (14.1%) is more than lumbarization (4.3%). That is in concurrence with the observations of the earlier observers. Hughes et al (2006), Steinberg (2003) and Hald et al (1995) reported lumbarization and sacralization to be 4.2% & 9.2%, 4.3% &14.0% and 5.9% &7.8% respectively. [9,20,22]

In present study, out of 38 lumbosacral transitional vertebra, 15(39.5%) showed unilateral changes whereas 23(60.5%) showed bilateral changes. Various clinical studies have shown that the unilateral defect types are more prevalent whereas in our study the bilateral defects are more common. It is because of the fact that the unilateral cases causes increased intensity of lower back pain due to uneven weight bearing and effect of the associated mass of the transitional vertebra causing pressure effect on the intervertebral disc or spinal nerves.

Castellvi et al (1976) reported type-II LSTV presents herniated lumbar disc at the level of transition and at the level just above the lumbosacral transitional vertebra.(6) Mogara et al (1978) reported high incidence (21.5%) of LSTV as the cause of Lower Back Pain and when associated with sacralization, it may be more severe. In our study, sacralization is the predominant Lumbosacral transitional vertebral anomaly encountered.[21]

The occurrence of lumbosacral transitional vertebra is linked to its embryological development and oesteological defects. Embryologically, the vertebra is bi-segmental in development and each vertebra receives contribution from caudal half of one sclerotome and from the cranial half of succeeding sclerotome.[1] All vertebras originate from mesodermal somites that form along the cranial caudal axis on either side of the notochord. Each somite differentiates into ventromedial part that is sclerotome and dorsolateral part that is Dermomyotome. Then sclerotomal cells migrate ventromedially around notochord to form vertebral bodies, then extend dorsally around neural tube to form vertebral arches and extend ventrolaterally to form transverse process and costal elements of ribs. Intervertebral disc are formed by sclerotomic fissure and mesodermal condensation.[1,2,4] The neural arch, pedicles and costal elements develop almost entirely from dense caudal half of each somite and thus attach to upper end of vertebral body. Thus lumbosacral transitional vertebra is caused by the border shifts, cranial shift resulting in the sacralization of the last lumbar vertebra and a caudal shift resulting in the lumbarization of the first sacral segment. Improper formation, migration, differentiation and union of somites results into segmental vertebral abnormalities. The cranial shifts often occurs at only one or two transitional border areas but caudal shifts involves three or four borders and the shifts are often in the same direction. The cranial shifts are dominant over the caudal shifts, so the sacralization is more common than lumbarization.[7,16]

Ossification defects are other potential cause of variation but it is highly difficult to differentiate between ossification defect and developmental defects as both results in the same morphology. Ossification occurs from 3 primary center and 7secondary centers in lumbar vertebra that ossifies between 17 & 25 years. Sacrum has 21 primary and 14 secondary center of ossification and ossifies at 25 years of age. Any defect in these ossification centers leads to variant morphology of the vertebra.[1,2,4]

Occurrence of lumbosacral transitional vertebra also results in the variation in segmental structure of vertebral column and alters biomechanics of the lumbar spine. Thus it leads to 23-25 mobile presacral vertebra.[2] There is limited motion between the transitional vertebra and sacrum due to anomalous articulation or bony fusion. At the level of transition, the load can be effectively absorbed by the fused transverse process or the aberrant joint decreasing motion and relieving stress on the intervertebral disc and preserve disc integrity whereas the resulting overwork at one level above LSTV can cause arthritis, disc changes or spinal cord compression. Increased disc degeneration above a LSTV is attributed to its relative hyper mobility.[22] The person may remain asymptomatic or may present with clinical symptoms that includes spinal or radicular pain, disc degeneration, L4/L5 disc prolapse, lumbar scoliosis and lumbar extradural defects.[4,5]

A transitional vertebra at the lumbosacral junction signifies that one vertebra in the lower back forms a part of the spine above, and is a part of the pelvis below. A transitional vertebra has the characteristics of two types of vertebrae. The first sacral vertebra may not fuse with the second resulting lumbarization of S-1 and person appears to have six lumbar vertebrae. Conversely, in sacralization of L-5 the individual appears to have four lumbar vertebrae.[6,22,24] The accurate assessment of the spinal segmentation is important in eliminating surgical and procedural errors due to variant spine anatomy including LSTV.[23,24]

CONCLUSION:

Present study shows a high prevalence (18.4%) of LSTV with sacralization (14.1%) and bilateral defects (60.5%) as predominant lumbosacral transition type

in the Central India population. Lumbosacral transition results in variation in segmental structure of vertebral column that demands vigilance and modifications during anesthetic and surgical intervention. It also results in formation of differential active motion segments and may be associated with non traumatic lower back pain and spinal pathologies. The study is of morphological importance in dealing with the large number of clinical cases related to lumbosacral region and is helpful for diagnostic and therapeutic purposes. Therefore, increased prevalence of lumbosacral transition demands clinical and radiological assessment prior to any interventional spinal anesthetic, obstetric and surgical procedure.

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