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**ORIGINAL RESEARCH**

# "Sacral hump": An unique radiological appearance for evaluation of lumbosacral transitional vertebra

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## ABSTRACT

**Background:** Lumbosacral transitional vertebra (LSTV) are congenital anomalies of spine which usually presents as either sacralisation of the L5 lumbar vertebra or lumbarisation of the S1 segment of sacrum with a prevalence of 4%-30% in world population. In plain radiographs we encounter these anomalies incidentally. Correct detection by X-Ray followed by proper numbering with MR TOP BOTTOM pasted image is essential. Wrong localisation can cause failed back syndrome. **Objective:** In 312 patients we foundfocal convexity at upper lateral margins of sacrum in plain X-Ray L.S (AP) view that we named "SACRAL HUMP". The accuracy of "SACRAL HUMP" in detecting lumbo-sacral transitional vertebra in plain radiographs by comparing with MR findings using localizers (TOP-BOTTOM pasted image) was the main aim of this study. **Method:** Observational type of cross-sectional study was done over 312 suspected LSTV cases with low back pain sent to Department of Radio-diagnosis from PMR, Orthopaedics and other OPD for conventional/digital X-Ray L-S spine. The results of X-Ray and MRI were correlated using ROC curve analysis and inter-rater agreement using kappa value. **Results:** Out of 312 cases, 230 had "sacral hump" morphology. The ability of "SACRAL HUMP" morphology to detect and correctly number LSTV segment in plain radiograph showed high sensitivity (100%,100%), specificity (90%,97%), P-value <0.001 and Kappa value of 0.91,0, 92 for sacralisation and lumbarisation respectively comparable to Gold standard (MR). **Conclusion**: Our observation of a specific contour variation-" sacral hump" has high positive predictive value, sensitivity and specificity in detecting and numbering LSTV (comparable to gold standard) and hence can be used as a screening test in non- traumatic low back painpatients not attributing to known degenerative, infective or inflammatory causes.

**Keywords:** LSTV, sacral hump, low back pain



## INTRODUCTION

Lumbosacral transitional vertebra (LSTV) is congenital anomalies of spine which usually presents as either sacralisation of the L5 lumbar vertebra or lumbarisation of the S1 segment of sacrum. The fusion of L5 vertebra with sacrum may be complete or incomplete. Similarly the lumbarisation of S1 vertebra may also be complete or incomplete. It is very essential to identify the lumbosacral transition vertebra correctly as failure to identify LSTV properly may lead to erroneous lumbar disc surgery which may lead to failed back syndrome.[1]

Lumbosacral transitional vertebra was observed for the first time by Bertolotti in 1917 and it is frequently encountered with a reported prevalence of 4%-30% in general population **[2]**.

Sacralisation most commonly occurs in L5 vertebra and rarely in L4 vertebra. However when L4 is sacralised the mobility and dynamics of L4 vertebra is altered which may lead increased stress in L4 vertebra leading to pain and discomfort for the patient. Bertolotti syndrome refers to the association between lumbosacral transitional vertebra (LSTV) and low back pain and can be an important cause in young patients. [3], [4], [5], [6], [7].

Sacralisation may lead to early disc degeneration, narrowing of intervertebral foramen and compression over spinal nerves.

The caudal half of one sclerotome and the cranial half of succeeding sclerotome contributes to formation of

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vertebra. The homeobox and paired box genes, Pax and Pax 9 regulates these process.[ 8].

LSTV is best imaged on Ferguson radiographs (with a cranial angle of 30° the radiographs are taken AP).

Currently, given its superior spatial resolution, CT is the best imaging technique for characterization of LSTVs. CT is not typically indicated solely to identify LSTV s, due to radiation concerns, nor is it the preferred imaging technique used to evaluate patients with non traumatic low back pain. In these clinical cases, MR imaging is more often indicated, given its superior tissue differentiation within and around the spine. The accurate assessment of spinal segmentation is crucial in eliminating surgical and procedural errors because most wrong-level spine surgery occurs in patients with variant spine anatomy, including LSTVs. Often, surgical error so occur when MR imaging of the lumbar spine is reported without MR TOP BOTTOM PASTED image.

## OBJECTIVE SO FSTUDY

- To analyze Age and Gender distribution in LSTV.
- Comparison of a specific contour abnormality of sacrum ("sacral hump") in plain radiograph with presence of LSTV in MRI using cervico-thoracic localizers (TOP-BOTTOM VIEW).
- Classification of LSTV cases into CASTELLVI TYPES both in X-Ray and MRI and frequency of occurrence of each type. Degree of concordance of Castellvi types between X-ray and MRI (taking MRI as GOLD STANDARD).
- To analyze the diagnostic performance of X ray in detecting lumbarisation and sacralisation separately based on presence of "SACRAL HUMP" taking MRI TOP BOTTOM PASTED IMAGE as GOLD STANDARD.
- To compare between Iliolumbar ligament attachment vs" sacral hump" in correctly diagnosing LSTV level. Disc height between LS-S1&S1-S2level as a predictor of sacralisation and lumbarisation.

## OBSERVATION IN OUR WORK

In LSTV patients we found focal convexity at upper lateral margins that we named "SACRAL HUMP". The presence of "SACRALHUMP" is a sign of presence of lumbo-sacral transitional vertebra."SACRAL HUMP" marks the fused transverse process of LS vertebra in cases of sacralisation or partially lumbar ised S1vertebra in case of lumbarisation. The type of LSTV can be further concluded based on counting downwards from T-12 vertebra recognised by the presence of T-12 rib. Often the T-12 rib is rudimentary /absent, so we must include the lower thoracic vertebrae in routine rdiograph of L-S spine for proper counting T- 11 and T-12 ribs are floating ribs, either anterior ends are not attached to sternum thus helping in easy recognition. However, due to great variation in the length of T-12 rib, vertebral counting from T-12 downwards can lead to fallacy, hence in this study we have (TOP-BOTTOM P A S T E D IMAGE) in MRI Sagittal plane as GOLD STANDARD for LSTV DIAGNOSIS. This change in morphology with LSTV mentioned in literature as follows:

Baetson (1894) observed that when a component of the axial skeleton assumes the morphology and function of its superior or inferior neighbour in distinction from meristic variation characterised by change in total number of component parts then the changes in vertebral counts area homeotic. When a n y in d iv id u a l has any variation in vertebral column it may be a result of either addition of a segment ( meristic) or change in identity of a series at the expense of other (homeotic) (Asheretal.2011)[10].

## METHODOLOGY

**STUDY DESIGN:** Analytical observational study of cross-sectional type.

**STUDY SETTING:** Patients recruited from various outpatient departments.

**PLACE OF STUDY:** Department of Radio-diagnosis, IPGME&R.

**STUDY POPULATION:** Patients attending various OPD with clinical symptoms of low back pain not attributed to trauma or any known chronic inflammatory or infective disease like Ankylosing spondylitis, DISH, Rheumatoid Arthritis, Spine Tuberculosis and suspected with LSTV on plain radiograph.

## SAMPLE SIZE AND SAMPLE DESIGN

As our study being observational in nature, we are not going for a formal sample size calculation. We have currently included 312 subjects in our study.

Design of the sampling is purposive.

## INCLUSION CRITERIA

- Patients who present with low back pain or buttock pain, excluding any known chronic inflammatory cause or trauma, suspected to have LSTV on X-RAY LS spine.
- Patients who are sent for preoperative assessment before a spinal surgery for excluding any lumbosacral vertebral anomaly and proper numbering of vertebra.
- Patients giving proper consent.

## EXCLUSION CRITERIA

- Patients where MRI is (Patients with neurostimulators, having cochlear implant, having pacemaker, metallic implants, and who are claustrophobic).
- Trauma patients with low back pain.
- Chronic inflammatory diseases like ankylosis

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spondylosis, DISH, Rheumatoid arthritis etc causing low back pain. Post operative cases of spine surgery.
- Patients who have not given proper consent for the examination.

**PARAMETERS TO BE STUDIED**
- To analyse Age and Gender distribution in LSTV.
- Comparison of a specific contoural abnormality of sacrum ("sacral hump") in plain radiograph with presence of LSTV in MRI using (Whole spine TOP-BOTTOM pasted image).
- To analyse the diagnostic performance of X-Ray in detecting lumbarisation and sacralisation separately based on presence of "SACRAL HUMP" taking MRI (Whole spine TOP-BOTTOM pasted image) as GOLD STANDARD.
- Classification of LSTV cases into Castellvi types both in X-Ray and MRI and frequency of occurrence of each type.
- Degree of Concordance of Castellvi types between X-ray and MRI (taking MRI as GOLD STANDARD).
- Classification of LSTV cases into CASTELLVI TYPES both in X-Ray and MRI and frequency of occurrence of each type. Degree of Concordance of Castellvi types between X-ray and MRI (taking MRI as GOLD STANDARD).
- To analyse overall diagnostic performance of X-RAY in correctly numbering the level of LSTV (Whole spine TOP- BOTTOM pasted image as GOLD STANDARD).
- To compare between Iliolumbar ligament attachment using MRI vs "sacral hump" using plain X-ray in correctly diagnosing LSTV level.
- Comparison of change of disc height between L5-S1 & S1-S2 with sacralization and lumbarization and calculating approximate cut off values of the same.

**STUDY TOOLS**

Conventional/Digital X-Ray Machine.

3.0 Tesla MRI machine, SIGNA 3T HDxt , GE healthcare with body coil (Torso phased array coil channel).

**STUDY TECHNIQUE**

Patients attending Department of Physical medicine and Rehabilitation OPD with low back pain were sent to Department of Radio-diagnosis for conventional/digital X-Ray L-S spine. Suspected Lumbosacral transitional vertebrae cases (LSTV) in X-Ray were further investigated by MRI. The results of X-Ray and MRI were correlated.

**STATISTICAL ANALYSIS PLAN**
- It has been done after completion of the study using standard and appropriate statistical method. Data collected was entered in Microsoft Excel spreadsheet. Data analysis was done using MedCalc version 11.6 [Mariakerke, Belgium: Med Calc Software 2011]. Chi-square test for continuous parametric variables, unpaired t- test used to compare means. For non- parametric variables Mann-Whitney test used. Ap value <0.05 was considered statistically significant.
- We have used 2 statistical methods in this study.
- **1. ROC curve analysis:** The capacity of a test to differentiate pathological cases from normal cases is assessed using Receiver Operating Characteristic (ROC) curve analysis (Metz, 1978; Zweig & Campbell, 1993). ROC curves may be used to collate the diagnostic accomplishment of two or more laboratory or diagnostic tests (Griner et al., 1981). In our study GOLD STANDARD investigation was considered MRI (TOP-BOTTOM PASTED IMAGE)

**Methodology**
- **DeLong et al**: Standard error of the area under the curve was calculated using the method of DeLong et al. (1988).
- **Youden index** has been used to determine cut off values, sensitivity and specificity. The Youden index J (Youden, 1950) is defined as: J = max {sensitivity c + specificity c - 1} where c ranges over all possible criterion values. Graphically, J is the maximum vertical distance between the ROC curve and the diagonal line.
- **2. Inter-rater agreement** was used to assess the concurrence between two classifications (nominal or ordinal scales). Concurrence is quantified by the Kappa (K) statistic (Cohen, 1960; Fleiss et al., 2003).

K = 1, is considered perfect concurrence. K= 0, is considered when there is no concurrence. When K is negative, the concurrence is worse than chance.

Inter-rater concurrence was used to compare degree of concurrence between findings of X-Ray and M.R.I.

**RESULTS AND ANALYSIS**
1. Out of 312 original cases, only 284 were suspected LSTV cases in plain radiograph.28 cases were not classified into either sacralisation or lumbarisation. These are few cases where either squaring of S1 or wedging of L5 vertebra was seen in lateral X- Ray, however counting in plain radiograph didn't show a LSTV. Hence these were included in our study.
2. Lowest presenting age was 15 yrs; highest presenting age was 76 yrs. Mean age of presentation was 41 yrs. Age group with maximum number of cases was 30-50 yrs with highest in 40-45 yrs. Although LSTV is a congenital anomaly, it is mostly an incidental finding when patient investigates for low back pain, hence the late presentation.
3. 47% cases were male and 53% cases were female.
4. CLASSIFICATION OF LSTV

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(SACRALISATION) INTO CASTELLVI TYPES BY X-RAY AND MRI.

| CASTELLVI TYPES | XRAY | % BY XRAY | MRI | % BY MRI |
|---|---|---|---|---|
| IA | 2 | 1 | 1 | 1 |
| IB | 8 | 3 | 9 | 4 |
| IIA | 30 | 12 | 27 | 11 |
| IIB | 51 | 21 | 57 | 24 |
| IIIA | 3 | 2 | 2 | 1 |
| IIIB | 131 | 54 | 119 | 50 |
| IV | 18 | 7 | 21 | 9 |
| TOTAL | 243 | 100% | 236 | 100% |

**ASSESSMENT OF DEGREE OF CONCORDANCE B/W X-RAY AND MRI USING COHEN'S KAPPA**

| | XR_CastellviType | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| MRICastellviType | IA | IB | IIA | IIB | IIIA | IIIB | IV | |
| IA | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 (0.4%) |
| IB | 1 | 6 | 0 | 0 | 0 | 0 | 1 | 8 (3.5%) |
| IIA | 0 | 0 | 25 | 1 | 0 | 1 | 0 | 27 (11.7%) |
| IIB | 0 | 0 | 1 | 47 | 0 | 7 | 3 | 58 (24.2%) |
| IIIA | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 3 (0.9%) |
| IIIB | 0 | 0 | 0 | 2 | 0 | 112 | 2 | 116 (50.2%) |
| IV | 0 | 1 | 4 | 1 | 0 | 4 | 11 | 21 (9.1%) |
| | 2 (0.9%) | 7 (3.0%) | 30 (13.0%) | 50 (21.2%) | 2 (0.9%) | 125 (53.7%) | 17 (7.4%) | 234 |
| Kappa | 0.812 | | | | | | | |
| 95% CI | 0.748 to 0.876 | | | | | | | |

*Green shaded boxes indicate the number of cases in which both MRI and X-Ray showed concordance to each other with respect to castellvi type.

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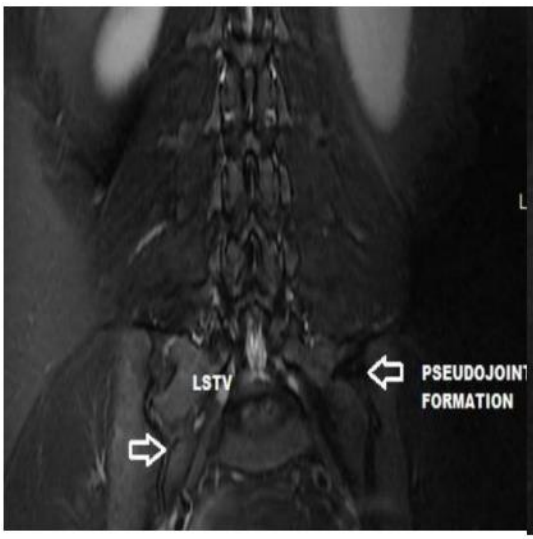


Figure A CASTELLVI II B

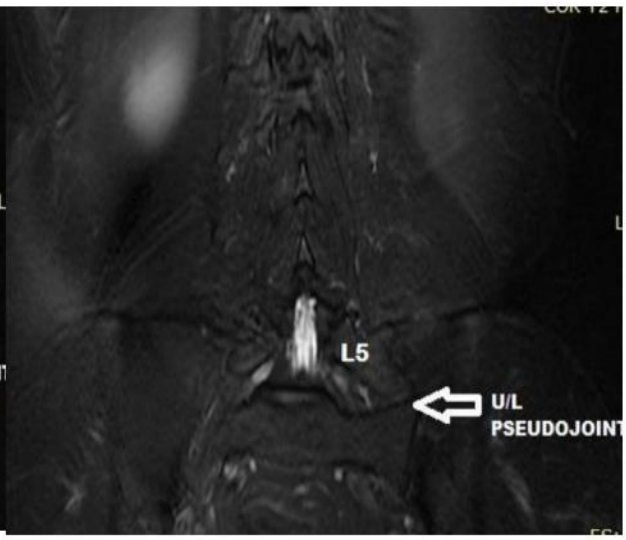


Figure B CASTELLVI II A


Figure C CASTELLVI III B

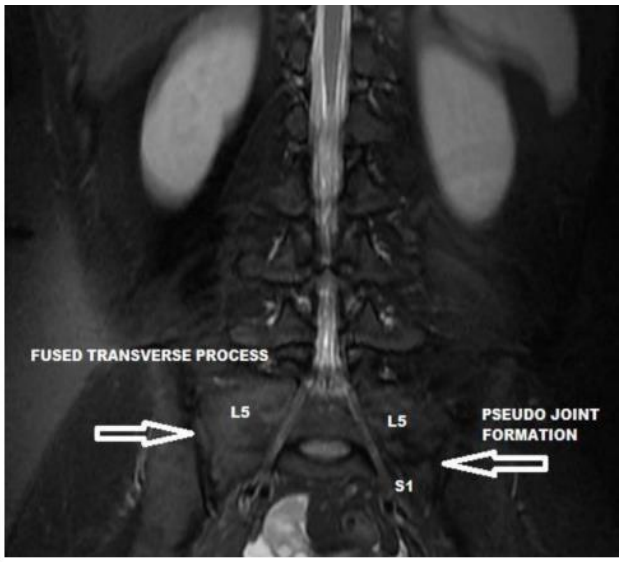


Figure D CASTELLVI I V

It was found that Type IIIB was most commonly found type both in X-ray and MRI. the degree of consensus between X-Ray and MRI findings with respect to Castellvi types for sacralisation was assessed using inter-rater agreement Cohen's Kappa value.The green shaded boxes in Inter-rater agreement table shows concordance values. Highest concordance was also noted between Castellvi type IIIB diagnosed by X-RAY and MRI. Cohen's Kappa value was 0.0812 which indicates "very good" concordance between results of X-ray and MRI.

5. DESCRIPTIVE ANALYSIS OF L5-S1 DISC HEIGHT IN CASES OF SACRALISATION

The lowest value was absence of disc space (0) and highest was 21. Mean and median values were 6.4 mm and 6mm respectively. ROC curve was plotted. A cut off of ≤7mm was found to have maximum sensitivity and specificity of 62% and 83% respectively. This result showed that L5-S1 disc height is not a sensitive parameter to detect sacralisation. This is justified as the values are very close to normal disc height between L5 & S1 vertebra.

6. DESCRIPTIVE ANALYSIS OF S1-S2 DISC SPACE (HEIGHT) IN CASES OF SACRALISATION

The lowest value was absence of disc space (0) and highest was 24 mm. Mean and median values were 0.8 cm and 0mm respectively. ROC curve was plotted. A cut off of ≤ 3.9mm was found tohave maximum sensitivity and specificity of 97% and 91% respectively. This result showed that S1-S2 disc height is sensitive and specific parameter to detect sacralisation and decrease with the same.

7. COMPARISON BETWEEN X-RAY AND MRI W.R.T "SACRAL HUMP" SUGGESTING SACRALISATION

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| | SACRALISATION IN MRI | LUMBARISATION IN MRI | NO LSTV IN MRI | TOTAL |
|---|---|---|---|---|
| SACRAL HUMP IN XRAY FOR SACRALISATION | 185 | 6 | 5+2(sq) | 198 |

*sq stands for squared appearance of S1vertebra

| | |
|---|---|
| Area under the ROC curve (AUC) | 0.949 |
| Standard Error [a] | 0.0135 |
| 95% Confidence interval [b] | 0.922 to 0.975 |
| z statistic | 33.240 |
| Significance level P (Area=0.5) | <0.001 |

[a] DeLong et al., 1988

Youden index

| | |
|---|---|
| Youden index J | 0.8976 |
| Associated criterion | >0 |
| Sensitivity | 100.00 |
| Specificity | 89.76 |

Criterion values and coordinates of the ROC curve

| Criterion | Sensitivity | 95% CI | Specificity | 95% CI | +LR | 95% CI | -LR | 95% CI |
|---|---|---|---|---|---|---|---|---|
| ≥0 | 100.00 | 98.0 - 100.0 | 0.00 | 0.0 - 2.9 | 1.00 | 1.0 - 1.0 | | |
| >0 | 100.00 | 98.0 - 100.0 | 89.76 | 83.1 - 94.4 | 9.77 | 5.8 - 16.4 | 0.00 | |
| >1 | 0.00 | 0.0 - 2.0 | 100.00 | 97.1 - 100.0 | | | 1.00 | 1.0 - 1.0 |

8. EXTENT OF AGREEMENT BETWEEN X-RAY AND MRI W.R.T. THIS PARAMETER BY CALCULATING COHEN'S KAPPA

P-value for our observation of "SACRAL HUMP" predicting sacralisation on plain X-ray by comparing these cases with gold standard (MRI TOP-BOTTOM VIEW). We found 198 "sacral hump" cases suggesting sacralisation on plain X-ray. These cases were investigated by Gold standard. 185(93%) among 198 were found sacralised.13 were either lumbarised (6) or had no LSTV (7). Sensitivity = 100%, Specificity = 90% and P-Value of <0.001 of this method was found which indicates that the results are highly significant and comparable to Gold Standard. Further extent of agreement between gold standard and x-ray with respect to this parameter by Cohen's kappa gave a value of 0.91 indicating "very good" agreement.

9. COMPARISON BETWEEN X-RAY AND MRI W.R.T "SACRAL HUMP" SUGGESTING LUMBARISATION

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| TABLE 12 | LUMBARISATION IN MRI | SACRALISATION IN MRI | NO LSTV | TOTAL |
|---|---|---|---|---|
| "SACRAL HUMP" IN XRAY FOR LUMBARISATION | 24(86%) | 0 | 8 | 32 |

| | |
|---|---|
| Area under the ROC curve (AUC) | 0.986 |
| Standard Error [a] | 0.00485 |
| 95% Confidence interval [b] | 0.977 to 0.996 |
| z statistic | 100.225 |
| Significance level P (Area=0.5) | <0.001 |

[a] DeLong et al., 1988

**Youden index**

| | |
|---|---|
| Youden index J | 0.9722 |
| Associated criterion | >0 |
| **Sensitivity** | 100.00% |
| **Specificity** | 97.22% |

Criterion values and coordinates of the ROC curve

| Criterion | Sensitivity | 95% CI | Specificity | 95% CI | +LR | 95% CI | -LR | 95% CI |
|---|---|---|---|---|---|---|---|---|
| ≥0 | 100.00 | 85.8 - 100.0 | 0.00 | 0.0 - 1.3 | 1.00 | 1.0 - 1.0 | | |
| >0 | 100.00 | 85.8 - 100.0 | 97.22 | 94.6 - 98.8 | 36.0 | 18.2 - 71.3 | 0.00 | |
| >1 | 0.00 | 0.0 - 14.2 | 100.00 | 98.7 - 100.0 | | | 1.00 | 1.0 - 1.0 |

EXTENT OF AGREEMENT BETWEEN X-RAY AND MRI W.R.T. THIS PARAMETER BY CALCULATING COHEN'S KAPPA

| | XR_SH for lumbarisation | | |
|---|---|---|---|
| MR_SH for lumbarisation | 0 | 1 | |
| 0 | 280 | 8 | 288 (92.0%) |
| 1 | 0 | 24 | 24 (8.0%) |
| | 280 (90%) | 32 (10%) | 312 |

| | |
|---|---|
| **Weighted Kappa[a]** | **0.91895** |
| Standard error | 0.04013 |
| 95% CI | 0.84029 to 0.99761 |

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We found 32 "sacral hump" cases suggesting lumbarisation on plain X-ray. These cases were investigated by Gold standard. 24 (86%) among 32 were found lumbarised.8 cases had no LSTV. Sensitivity = 100%, Specificity = 97% and P-Value of <0.001 of this method was found which indicates that the results are highly significant and comparable to Gold Standard. Further extent of agreement between gold standard and x-ray with respect to this parameter by Cohen's kappa gave a value of 0.918 indicating "very good" agreement.

10. DIAGNOSTIC PERFORMANCE OF "SACRAL HUMP" MORPHOLOGY TO CORRECTLY NUMBER THE LEVEL OF LSTV (SACRALISATION /LUMBARISATION) USING PLAIN RADIOGRAPH IN COMPARISON TO GOLD STANDARD (TOP-BOTTOM VIEW IN MRI

Total number of "SACRAL HUMP" cases was 230 out of 312. 215(93%) were positive for LSTV by gold standard investigation out of 230 cases. ROC curve was plotted to analyse sensitivity, specificity and P-value of this parameter. Sensitivity= 100%, Specificity=80% and P-Value <0.001 which indicates this parameter is highly sensitive and specific in detecting and numbering LSTV when found in plain radiograph.

11. Out of 312 sample size, in 245 cases ilio-lumbar was attached to L5, and in 67 cases iliolumbar ligament was attached to other vertebrae. By iliolumbar ligament attachment site solely using coronal/axial images without using TOP-BOTTOM view, LSTV was positive in 234 cases and negative in 78 cases. Gold standard investigation revealed LSTV + in 292 cases and absent in 20 cases. Sensitivity, specificity and P-value was studied using ROC curve. Sensitivity was 80%, specificity was 55% and a P-value of 0.03. This indicates that iliolumbar ligament attachment site is neither a sensitive nor a specific test to detect and number LSTV.
12. COMPARISON (ROC CURVES) BETWEEN DIAGNOSTIC VALUE OF "ILIO-LUMBAR LIGAMENT ATTACHMENT SITE" IN MRI VS "SACRAL HUMP APPEARANCE" IN X-RAY IN DIAGNOSING LSTV LEVEL

**ANALYSIS:** We have compared ROC curves of 2 methods of detecting and numbering LSTV.

**METHOD 1**: Detecting LSTV using "sacral hump" morphology, then counting from T-12 vertebra (identifying T-12 vertebra using number & morphology of floating ribs) using plain radiograph L-S spine.

**METHOD 2:** Detecting and counting the level of LSTV by the attachment site of ilio-lumbar ligament using MRI L-S spine (without TOP-BOTTOM PASTED IMAGE).

The difference of AUC (0.283) was significant statistically. P –value = <0.0001(highly significant). METHOD 1 was a better diagnostic test of the two with a sensitivity of 100% and specificity of 80%.

13. Out of 312 sample size, 243 were diagnosed sacralisation by X-Ray using all parameters. However, Gold standard diagnosed, out of 312 cases, 236 were actual sacralisation cases. True positive cases were 231 in number and 12 cases were false positive cases. This was plotted using ROC curve to analyse the sensitivity, specificity and P-value of X-Ray as a diagnostic test to detect sacralisation in comparison to gold standard. Sensitivity=97%, Specificity=84%, and P-value<0.001 indicating highly significant results.
14. Out of 312 sample size, 41 were diagnosed lumbarisation by X-Ray using all parameters. However, Gold standard diagnosed, out of 312 cases, 56 were actual lumbarisation cases. True positive cases were 36 in number and 5 cases were false positive cases. False negative cases were 20. This was plotted using ROC curve to analyse the sensitivity, specificity and P-value of X-Ray as a diagnostic test to detect sacralisation in comparison to gold standard. Sensitivity=64%, Specificity=98%, and P-value<0.001 indicating highly significant results. We can see sensitivity is less for detecting lumbarisation by X-ray. This is due to increase in number of false negative cases. This error can be attributed to cases were complete lumbarisation was present with presence of a lumbar rib or partial lumbarisation without any "sacral hump" formation seen in X-ray.

## DISCUSSION

- We have done a cross-sectional study of 312 subjects attending Outpatient department of Physical medicine and rehabilitation (P.M.R) with low back pain not attributed to any infective, inflammatory or post–traumatic etiology. The type of sampling used in this study was non-probability purposive sampling method, as our research was qualitative in nature. 312 cases were suspected to have LSTV by plain radiograph (X-Ray L-S spine) which were further investigated using MRI L-S spine with Cervico-thoracic localizer (TOP-BOTTOM pasted image). MRI TOP-BOTTOM VIEW was considered GOLD STNDARD in our research.
- In our study we have suspected LSTV using all the parameters (enlarged transverse process, pseudoarthrosis, fusion, squaring and wedging at lumbosacral region) already known in literature on plain radiograph. Additionally, our observation was that a specific contoural abnormality (focal convexity at upper margin of sacral ala) which we named "SACRAL HUMP" was useful in detecting LSTV. (This criterion was

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also used in our study to detect LSTV).

- We have depicted that out of 312 suspected LSTV on X-Ray, 292 were disease positive and 20 were negative by Gold Standard investigation. So LSTV detection rate by X-Ray alone was 93.5%.
- Out of 292 disease positive cases 236 were sacralisation and 56 were lumbarisation in the ratio 4:1. Sacralisation is the commoner LSTV.
- Gender distribution analysis showed 47% were male patients and 53% were female patients in sample size.
- Among 236 cases of sacralisation, 94 were male and 142 were females and the ratio of male to female with sacralisation is approximately 1:2. Universatility of lumbarisation / sacralisation in various studies: [41, 42, 44].
- In most of the studies ratio of sacralisation: lumbarisation is in the range of 2-3:1 except in study by Kim et al.[42] In our study ratio is 4:1..This difference may be attributed to gender distribution in sample size in our study and a different study population. It is seen lumbarisation is commoner in males. In our study female cases are more in number. H o w e v e r , sacralisation is commoner LSTV in almost all previous studies and our results agree with them.
- Castellvi TYPE III B (Fusion on both sides) was most commonly found type in this study [119(50%) out of 236 ]. It was also most frequently associated with "Sacral hump" morphology.
- Rarest type and most asymptomatic type was Castellvi type IA. Scoliosis was usually associated with unilateral affection (Castellvi IIA, IIIA).
- Similarly, ROC curve analysis to determine cut-off w.r.t. MRI S1-S2 disc space that predicts sacralisation and lumbarisation was done. It revealed cut off values to be ≤3.9 and >4.9 respectively. Sensitivity 97% and 96% respectively. Specificity 91%and 94% respectively. It can be inferred that S1-S2 disc height change predicts sacralisation and lumbarisation more accurately than change in L5-S1 disc height.
- 230 cases of "SACRAL HUMP" morphology was observed in this study by X-Ray.Using the method of counting from T-12 vertebra, out of 230 cases of "SACRAL HUMP" morphology ,198 were suspected sacralisation and 32 were suspected lumbarisation in plain radiograph.Out of 198 suspected sacralisation, 185 (93%) was diagnosed sacralisation by Gold standard. Sensitivity, specificity and P- value was calculated by ROC curve. Sensitivity was 100% and specificity 90%. P-value= <0.001 (highly significant). The results of this method were comparable to Gold standard.Inter rater agreement using Cohen's Kappa was 0.91 which indicates "very good" agreement between this test and gold standard.
- Out of 32 suspected lumbarisation by "SACRAL HUMP" morphology, 24(86%) was diagnosed lumbarisation by Gold standard. Sensitivity was 100% and specificity 97%. P-value <0.001 (highly significant). The results of this method were also comparable to Gold standard.
- Inter rater agreement using Cohen's Kappa was 0.92 which indicates "very good" agreement between this test and gold standard.
- Together the sensitivity, specificity of this method using "Sacral hump" morphology to detect LSTV and counting from T-12 vertebra (as described above) to correctly ascertain the level of LSTV (sacralisation/lumbarisation) was 100% and 80% respectively

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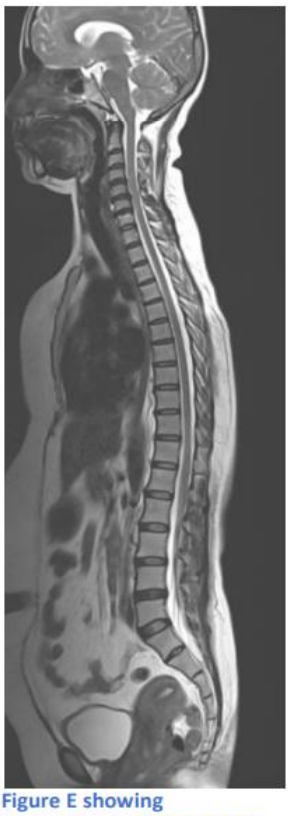


Figure E showing sacralisation of L5 vertebra.

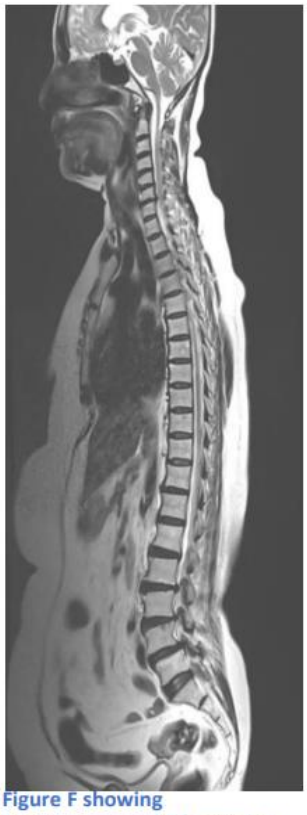
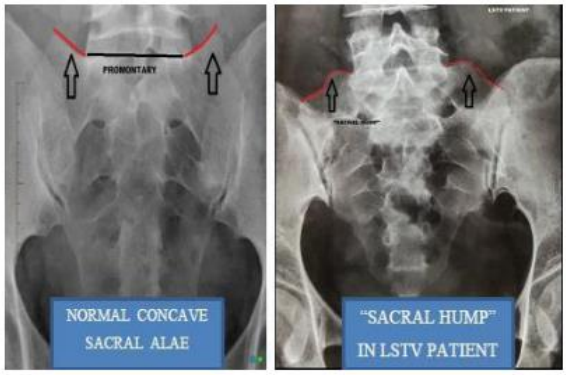


Figure F showing lumbarisation of S1 vertebra.



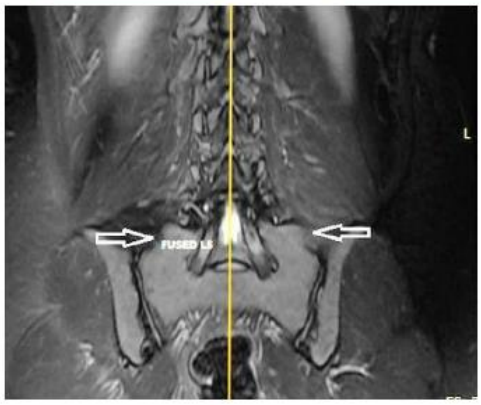




Figure G showing SACRAL HUMP

- We have compared ROC curves of these 2 above mentioned methods.

**METHOD 1**: Detecting LSTV using "sacral hump" morphology, then counting from T-12 vertebra (identifying T-12 vertebra using number & morphology of floating ribs) using plain radiograph L-S spine.

**METHOD 2:** Detecting and counting the level of LSTV by the attachment site of ilio-lumbar ligament using MRI L-Spine (without TOP-BOTTOM view).

The difference of AUC was significant statistically. P –value = <0.0001(highly significant). METHOD 1 was a better diagnostic test of the two with a sensitivity of 100% and specificity of 80%.

Finally, overall diagnostic performance of X-RAY in detecting sacralisation and lumbarisation using all parameters (enlarged transverse process, pseudoarthrosis, fusion, squaring and wedging of vertebrae at lumbosacral region along with our observation of "sacral hump") was studied with respect to Gold standard.

**FOR SACRALISATION**
SENSITIVITY: 97%
SPECIFICITY: 84%
P-VALUE: <0.001

**FOR LUMBARISATION**
SENSITIVITY: 63%
SPECIFICITY: 98% P-VALUE:<0.001

**LIMITATIONS**

- Due to time constraints sample size could be limited to 312 cases. Larger sample size would give more accurate statistics.
- Prevalence could not be calculated from this study as sampling was non-probability purposive sampling including only suspected LSTV cases among low back pain cases and not random LBP cases,
- Observer bias is a limitation in purposive sampling.
- Blinding was not applied while evaluating X-ray and MRI of same case. X-Ray was done followed by MRI. So, results may be biased.
- Our observation of "SACRAL HUMP" could not be supported by any previous literature. So, the findings related to this parameter needs further studies for confirmation.

**CONCLUSION**

Sacralisation is more common than lumbarisation, approximately in the ratio of 4:1.

CASTELLVI type IIIB was most commonly found, also most commonly associated with "sacral hump" morphology and low back pain.

We have done a study with our observation of a specific contoural abnormality "SACRAL HUMP" for detecting and numbering LSTV along with other known parameters. The ability of "SACRAL HUMP" morphology to detect LSTV in plain radiograph and correctly number the level of LSTV showed a high sensitivity (100%), specificity (80%) and P-value

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<0.001 comparable to Gold standard (MR Top-bottom pasted image). This method can be used as an important screening investigation to detect LSTV. It can even replace the need of MRI for sole detection of LSTV considering the cost issues associated with MR investigation.

## REFERENCES

1. Malanga GA, Cooke PM. Segmental anomaly leading to wrong level disc surgery in cauda equina syndrome. *Pain Physician* 2004 ; 7 : 107-110.
2. Lumbosacral Transitional Vertebrae: Classification, Imaging Findings, and Clinical RelevanceG.P. Konin and D.M. WalzAmerican Journal of Neuroradiology November 2010, 31 (10) 1778-1786; DOI: https://doi.org/10.3174/ajnr.A2036.
3. Delport EG, Cucuzzella TR, Kim N, et al. Lumbosacral transitional vertebrae: incidence in a consecutive patient series. Pain Physician 2006;9:53–56PubMedGoogle Scholar
4. Luoma K, Vehmas T, Raininko R, et al. Lumbosacral transitional vertebra: relation to disc degeneration and low back pain. Spine 2004;29:200–05
5. Taskaynatan MA, Izci Y, Ozgul A, et al. Clinical significance of congenital lumbosacral malformations in young male population with prolonged low back pain.Spine 2005;30:E210–13CrossRefPubMedGoogle Scholar
6. Peh WC, Siu TH, Chan JH. Determining the lumbar vertebral segments on magnetic resonance imaging.Spine 1999;24:1852–55CrossRefPubMedGoogle Scholar
7. Tabor ML. Statistical study of anomalies of the lumbar and lumbosacral vertebrae: radiologic findings from 7,500 orthopedic patients [in French]. J RadiolElectrol Med Nucl1968;49:713–18PubMedGoogle Scholar
8. ] A STUDY OF SACRALISATION OF FIFTH LUMBAR VERTEBRA IN GUJARAT Kubavat Dharati1, Nagar SK2, Malukar Ojaswini3, Trivedi Dipali4, Shrimankar Paras4, Patil Sucheta5
9. G.P. Konin and D.M. Walz.American Journal of Neuroradiology November 2010, 31 (10) 1778-1786; DOI: https://doi.org/10.3174/ajnr.A2036
10. Asher, R., Lin, K., Kardjilov, N. &Hautier, L., 2011. Variability and constraint in the mammalian vertebral column. *Journal of Evolutionary Biology*, 24(5), pp.1080–1090.
11. Leboeuf C, Kimber D, White K. Prevalence of spondylolisthesis, transitional anomalies and low intercrestal line in a chiropractic patient population. *J Manipulative Physiol Ther* 1989 ; 12 :200-204.
12. Kim YH, Lee PB, Lee CJ, et al. Dermatome variation of lumbosacral nerve roots in patients with transitional lumbosacral vertebrae. *AnesthAnelg*2008;106:1279–83
13. Peh WC, Siu TH, Chn JH.Determining the lumbar vertebral segments on magnetic resonance imaging. *Spine* 1999;24:1852–55.