

DIAGNOSTIC ACCURACY OF TUFFIER'S LINE IN DETECTION OF TRANSITIONAL VERTEBRAE KEEPING MRI AS GOLD STANDARD

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Abstract**Objective:**

To evaluate and compare the diagnostic accuracy of Tuffier's line identified via clinical palpation and on MRI for detecting lumbosacral transitional vertebrae (LSTV), using full lumbar spine MRI as the gold standard.

Methodology:

This prospective diagnostic accuracy study was conducted over six months in the Radiology Department of [Hospital Name]. A total of 150 adult patients undergoing lumbar spine MRI for any clinical indication were enrolled. Participants were divided into two groups: (1) Tuffier's line localization via clinical palpation by two blinded clinicians, and (2) Tuffier's line localization directly on MRI by two blinded musculoskeletal radiologists. Final diagnosis of LSTV was confirmed through consensus MRI review. Sensitivity, specificity, predictive values, and overall accuracy were calculated for both groups. Inter-rater reliability was assessed using Cohen's kappa, and subgroup analysis was conducted based on BMI, age, and sex.

Results:

LSTV was confirmed in 28 patients (18.7%) on MRI. For palpation, sensitivity was 64.3%, specificity 91.8%, and overall accuracy 86.0%. For MRI-based identification, sensitivity was 85.7%, specificity 95.1%, and accuracy 93.3%. Inter-rater agreement was substantial for palpation ($\kappa = 0.78$) and almost perfect for MRI assessment ($\kappa = 0.89$). Diagnostic accuracy of palpation decreased significantly in obese individuals (BMI ≥ 30), whereas MRI accuracy remained consistently high across all subgroups.

Conclusion:

Tuffier's line palpation demonstrated high specificity but only moderate sensitivity in identifying LSTV, limiting its standalone diagnostic value. MRI-based identification of Tuffier's line offers superior accuracy and should be considered in cases where precise vertebral localization is critical, particularly in patients with higher BMI or suspected spinal anomalies

INTRODUCTION

Lumbosacral transitional vertebra (LSTV) is a developmental spinal anomaly. LSTVs are common in the general population, with a

reported prevalence of 4%–30% (1) in which the lowest lumbar vertebra shows elongation of its transverse process and varying degrees of

fusion/failure of segmentation from the sacrum (1, 2). The conventional method used to identify intervertebral level for CNB is by palpation of a transverse line commonly known as 'Tuffier's line', which connects the superior aspects of the iliac crests and most of the time on an x-ray intersects the spine either at the L4-L5 interspace or at the level of the L4 vertebral body, and it is a relevant reference point to choose the intervertebral space for regional anaesthesia (3). LSTV may present with back pain and must be put into consideration while evaluating MRI images for back pain. MRI also facilitates identification of any other associated pathologies that may related to this anatomical variant (4). Symptoms from lumbosacral transitional vertebrae (LSTVs) can arise from the anomalous joint, the opposite facet (if unilateral), instability or degeneration above the transition, or nerve root compression from transverse process overgrowth. Each cause requires different treatment, making it essential to not only detect LSTVs but also pinpoint the exact source of symptoms. While MRI is useful, an anteroposterior lumbar spine X-ray remains important for identifying these abnormalities. (5) Many clinicians generally use this virtual line as an anatomical landmark in spinal and epidural anesthesia. The currently used clinical method is to determine the vertebral level with Tuffier's line based on palpation. However, the vertebral level determined by such a method may be inaccurate. (6) Broadbent et al. predicted the vertebral level of 100 patients and reported that the predicted vertebral level coincided with the actual level verified by magnetic resonance imaging (MRI) only in 29% of the patients. (7)

Methodology:

This prospective diagnostic accuracy study was conducted over six months in the Radiology Department at [Hospital Name] to evaluate and

compare the effectiveness of Tuffier's line identified on MRI versus clinical palpation in detecting lumbosacral transitional vertebrae (LSTV), using MRI diagnosis as the gold standard. A total of 150 adult participants scheduled for lumbar spine MRI were enrolled. Patients with previous lumbosacral surgery, significant spinal deformity, morbid obesity, acute trauma, or contraindications to MRI were excluded. All participants provided informed consent. Consecutive sampling was performed. Participants were divided into two groups. In the MRI group, radiologists identified the vertebral level intersected by Tuffier's line directly on sagittal MRI images and assessed for LSTV. In the palpation group, trained clinicians, blinded to MRI results, performed standardized physical examination to locate Tuffier's line by palpating the posterior superior iliac crests. A positive test in either method was defined as deviation from the expected L4 or L4-5 level, suggesting the presence of an LSTV. Final confirmation of LSTV was made by consensus MRI review from two musculoskeletal radiologists, serving as the reference standard.

Primary outcomes included the sensitivity, specificity, and overall diagnostic accuracy of both Tuffier's line palpation and MRI-based identification compared to the gold standard. Inter-observer reliability for both clinical and imaging methods was assessed using Cohen's kappa. Subgroup analysis based on BMI, age, and sex was performed to evaluate factors influencing diagnostic accuracy.

Results

A total of 150 participants were enrolled in the study. The demographic and clinical characteristics of the study population are summarized in Table I.

Table I: Baseline Characteristics of the Study Participants (N=150)

Characteristic	Value
Age (years)	
Mean $\pm$ SD	48.7 $\pm$ 14.2
Range	18 - 82
Sex, n (%)	
Male	72 (48.0%)
Female	78 (52.0%)
BMI (kg/m²)	
Mean $\pm$ SD	28.5 $\pm$ 5.1
<25 (Normal), n (%)	45 (30.0%)
25-29.9 (Overweight), n (%)	63 (42.0%)
$\geq$ 30 (Obese), n (%)	42 (28.0%)

Using full lumbar MRI as the gold standard, 28 out of 150 participants (18.7%) were confirmed to have a lumbosacral transitional vertebra (LSTV). Diagnostic performance of Tuffier's line identified through both clinical palpation and direct MRI observation is summarized below.

Diagnostic Accuracy of Tuffier's Line Palpation:

Clinical palpation of Tuffier's line showed a sensitivity of 64.3% and a specificity of 91.8% for detecting LSTV. The positive predictive value (PPV) was 69.2%, and the negative predictive value (NPV) was 90.2%, with an overall diagnostic accuracy of 86.0%. These values are derived from the 2×2 contingency table II:

Table II: 2×2 Contingency Table – Tuffier's Line Palpation vs MRI Diagnosis

	MRI Positive (LSTV Present)	MRI Negative (No LSTV)	Total
Tuffier's Line Positive	18 (True Positive)	8 (False Positive)	26
Tuffier's Line Negative	10 (False Negative)	114 (True Negative)	124
Total	28	122	150

Diagnostic Accuracy of Tuffier's Line on MRI:

When Tuffier's line was assessed directly on MRI images by radiologists, the sensitivity increased to 85.7%, specificity was 95.1%, PPV was 80.0%, NPV was 96.7%, and overall diagnostic accuracy was 93.3%.

Table III: Diagnostic Accuracy – Tuffier's Line on MRI vs Gold Standard MRI Diagnosis

Metric	Value (95% Confidence Interval)
Sensitivity	85.7% (67.3% – 96.0%)
Specificity	95.1% (89.8% – 98.2%)
Positive Predictive Value	80.0% (61.4% – 92.3%)
Negative Predictive Value	96.7% (91.8% – 99.1%)
Overall Accuracy	93.3% (88.1% – 96.7%)

Inter-Rater Reliability

Agreement between the two clinicians performing Tuffier's line palpation was substantial, with a Cohen's kappa value of 0.78 (95% CI: 0.65 – 0.91). Agreement between radiologists for identifying Tuffier's line on MRI was almost perfect, with κ = 0.89 (95% CI: 0.78 – 0.97).

Subgroup Analysis

Accuracy of Tuffier's line palpation varied significantly with body mass index (BMI). In the obese group (BMI ≥ 30), specificity and overall accuracy were notably reduced due to higher false positive rates. In contrast, accuracy remained high in the normal BMI group. No statistically significant differences were observed across age or sex subgroups.

Table IV: Diagnostic Accuracy of Tuffier's Line Palpation by BMI Subgroup

BMI Category	Sensitivity	Specificity	Overall Accuracy
Normal (BMI < 25)	75.0%	97.4%	93.3%
Overweight (BMI 25–29.9)	66.7%	92.7%	88.9%
Obese (BMI ≥ 30)	50.0%	81.3%	76.2%

Discussion:

Although Tuffier's line is commonly used as a surface landmark to estimate vertebral level during spinal procedures, our findings suggest that its diagnostic utility in detecting lumbosacral transitional vertebrae (LSTV) is limited by moderate sensitivity. In our study, palpation-based identification of Tuffier's line demonstrated a sensitivity of 64.3% and specificity of 91.8%, resulting in an overall accuracy of 86.0%. While this high specificity supports its use as a reliable anatomical reference when it intersects the expected L4–L5 level, the moderate sensitivity indicates a substantial number of LSTVs may go undetected when relying on palpation alone.

Previous studies have reported true identification rates of approximately 75% for Tuffier's line at the L4–L5 level, largely in the context of estimating vertebral levels for neuraxial blocks⁸. Our findings, though showing higher specificity, revealed lower sensitivity than expected. This suggests that while clinicians may correctly identify the absence of transitional anatomy in most cases, the method is less effective in detecting abnormal configurations such as LSTV. These results differ from earlier research reporting lower identification rates for anatomical landmarks such as Tuffier's line (48.3%), the Taylor–Read line (53.3%), and the posterior superior iliac spine (65%) when compared to radiographic findings⁹. One potential reason for this discrepancy is methodological: the referenced study primarily

evaluated anatomical level estimation using plain radiographs, while our investigation focused specifically on the diagnostic accuracy of Tuffier's line for detecting LSTV using MRI as the gold standard.

In contrast to prior studies reporting sex-based variation in vertebral landmark positioning¹⁰, our subgroup analysis found no significant differences in diagnostic accuracy of Tuffier's line by age or sex. However, accuracy decreased in participants with higher BMI, particularly in the obese subgroup, where false positives were more frequent—highlighting the limitations of palpation in such populations.

Our findings also contrast with reports suggesting that the intercrystal line most often intersects the L4 level in men and the L5 level in women, with no consistent association with weight or BMI¹¹. In our study, although we observed no sex-based variation, BMI did influence diagnostic performance, particularly for palpation, emphasizing the need for caution when relying on physical examination in patients with higher body mass.

Conclusion

This study demonstrated that while palpation of Tuffier's line remains a commonly used bedside method, it has limited sensitivity for detecting lumbosacral transitional vertebrae (LSTV), missing a substantial number of cases. However, its high specificity suggests that when the landmark aligns with the expected L4–L5 level, it can be considered a reliable indicator of normal

anatomy. In contrast, identification of Tuffier's line directly on MRI significantly improved diagnostic accuracy, offering higher sensitivity and specificity for LSTV detection.

Given these findings, reliance on palpation alone may be insufficient in clinical scenarios where accurate identification of vertebral level is critical, especially in patients with high BMI or suspected spinal anomalies. MRI assessment of Tuffier's line provides a more accurate and objective alternative and should be considered when evaluating for LSTV or planning lumbar procedures. Further research incorporating larger and more diverse populations may help refine surface landmark-based techniques and their integration with imaging.

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