



# A review of 571 radiographs on Tuffier's inter-cristal line and its' application in lumbar spinal surgery

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**Background:** Tuffier's line (TL) is an anatomical landmark used to identify the L4/5 interspace by palpating inter-cristal level in lumbar spinal surgery. The routine use of pre-operative pre-incision radiographs for level check by spinal surgeons is variable due to reliance on this palpation. The anatomical violation of neighbouring normal levels in microscope assisted lumbar surgery is unknown. The aim of this study was to evaluate the effects of patient-related demographic factors and radiographic parameters on TL in a cohort of patients undergoing lumbar spinal procedures.

**Methods:** We retrospectively analysed 195 patients (571 radiographs) from a spinal database undergoing lumbar spinal procedures included nerve root injections, decompressions, micro-discectomies and instrumented fusions under a single surgeon. Radiographs were analysed with regard to age, gender, radiographic views (AP & lateral) and weight-bearing (wb) & non-weight bearing (non-wb).

**Results:** The mean age was 59.8 years (range, 24–88 years). The most common level of TL was L4 vertebra (40% <60; 44% >60 years). The most common level in females was L5, while in males L4 vertebra. In 186 radiographs, 68% displayed a difference of at least one vertebral level on AP versus lateral planes. In 11 patients, there was at least 1 level vertebral difference between weight bearing & non-weight bearing radiographs.

**Conclusions:** TL can be affected by age, gender, radiographic views and weight bearing status variably. We recommend employing pre-incision radiographs in all microscope assisted lumbar spinal procedures to eliminate the clinical variations in inter-cristal line and thereby avoiding anatomical violation of neighbouring normal levels in microscope-assisted lumbar surgery. We highlight such variations in inter-cristal line should be given enough consideration in order to avoid a wrong level surgery. Palpatory method for level check without performing pre-incision lateral X-ray should be discouraged.

**Keywords:** Tuffier's line (TL); lumbar surgery; gender; X-ray

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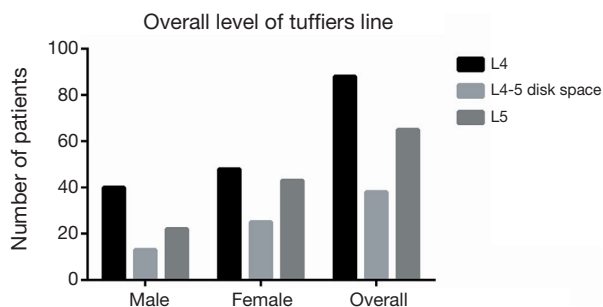
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## Introduction

Tuffier's line (TL) is defined as the anatomical landmark that intersects the highest point of the iliac crests and believed to be passing through the L4 vertebral body. It

has traditionally seen application in the setting of spinal anaesthesia and the performance of lumbar puncture (1). To our knowledge, the application of TL has only been reported in the realms of anaesthesia, neurology and chiropractic practice. In the published literature,



**Figure 1** The distribution of Tuffier's line in relation to vertebral levels in males, females and an overall count of the population.

TL has been reported as an unreliable anatomical landmark. Gender has been shown to vary in determining the level of TL; typically, in males a level higher, whilst in female counterparts a level lower. Several reports demonstrated that BMI, age & height do not influence the position of TL (2-6).

The routine use of pre-operative pre-incision radiographs for level check by spinal surgeons is variable due to reliance on this palpation. The anatomical violation of neighbouring normal levels in microscope assisted lumbar surgery is unknown. The use of TL to guide the level of lumbar surgery as a pre-incision check has important ramifications for patient safety. In a survey reporting pre-level spinal checks amongst spinal surgeons, it was demonstrated that 7% of surgeons do not perform pre-incision radiographical checks (7). The investigation of the reliability of this landmark is important as failure to do so could lead to wrong level surgery and compromised patient care. There are no studies published in the literature to evaluate clinico-radiological correlation of TL in lumbar spinal surgery.

The aim of this study was to evaluate the effects of patient-related demographic factors (age & gender) and radiographic parameters (type of X-ray views & weight bearing status) on TL in a cohort of patients undergoing lumbar spinal procedures.

## Methods

This study is a retrospective analysis of 195 patients identified from a spinal database with evaluation of the level of TL in 571 radiographs. These patients underwent a variety of lumbar spinal procedures including nerve root injections, decompressions, micro-discectomies and instrumented fusions. Patients with spinal deformities were excluded.

Plain radiographs were analysed with regard to age, gender, radiographic views (antero-posterior & lateral), weight bearing (wb *vs.* non-wb) & dynamic radiographs (flexion & extension) to determine if there was a difference in the level of TL.

TL was determined by the horizontal intersect across the highest points of the iliac crest as identified on X-rays. Intersection was recorded as L3 vertebra, L4 superior endplate, L4 upper vertebral body, L4 lower vertebral body, L4 inferior endplate, L4-L5 disc space, L5 superior endplate, L5 upper vertebral body, L5 lower vertebral body & L5 inferior endplate.

Statistical analysis included the expression of variable data in the form of mean, standard deviation & 95% confidence intervals as descriptive statistics. Unpaired *t*-test was used to evaluate age gender and radiographic views. P value of <0.05 was considered as statistically significant.

## Statement of ethics approval

Ethical approval was not required as this was radiology evaluation of previously treated patients. All patient data were anonymised prior to synthesis.

## Results

There were 195 patients of which 121 were female (62.1%) and 74 (37.9%) were male patients. The mean age was 59.8 years (range, 24 to 89 years).

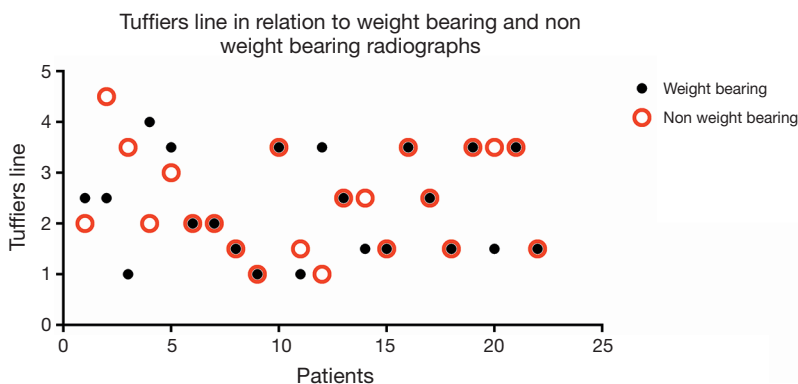
The distribution of TL in relation to vertebral levels in all patients revealed that L4 was the level of TL in 81 patients (43.3%), through the L4-5 disc space in 44 patients (23.5%) and at the level of L5 vertebra in 62 (33.1%) patients (*Figure 1*).

## Age specific variation in TL

On analysing patients' age in relation to TL, we divided patients into aged under and over 60 years. There was a statistically significant difference between the ages of under and over 60 with a P value of 0.001.

## Gender specific variation in TL

In females, Tuffier's line tended to pass through the L5 superior endplate or L5 body; in males, it tended to pass through the L4 body. The distribution of TL in relation to gender has been shown in *Figure 1*. There was a significant



**Figure 2** A graph representing the difference in weight bearing and non-weight bearing radiographs. Twenty-two patients who had X-rays both weight bearing and non-weight bearing; 11 of these patients reported a difference of 1 vertebral level between the two positions.

**Table 1** Location of Tuffier’s line in the lateral view

| Spinal level         | Overall population (N=195), n, % (95% CI) | Male (N=70), n, % (95% CI) | Female (N=125), n, % (95% CI) |
|----------------------|---|----------------------------|-------------------------------|
| L3 body              | 4, 2.0 (5–5%)                             | 1, 1.4 (1–8%)              | 3, 2.3 (5–7%)                 |
| L4 body              | 86, 43.4 (37–51%)                         | 34, 48.6 (37–60%)          | 52, 40.6 (32–59%)             |
| L4 inferior endplate | 5, 2.5 (0–5.9%)                           | 0, 0                       | 5, 3.9 (1–9%)                 |
| L4–L5 disk level     | 46, 23.2 (11–21%)                         | 20, 28.6 (29–51%)          | 22, 20.3 (14–28%)             |
| L5 superior endplate | 7, 3.5 (1.5–7%)                           | 1, 1.4 (1–8%)              | 6, 4.7 (1–10%)                |
| L5 body              | 46, 23.2 (18–30%)                         | 4, 5.7 (1–14%)             | 41, 32.8 (25–41%)             |

n indicates number of subjects; CI, confidence interval.

difference between females and males in the lateral view with a P value of 0.0478.

**Weight bearing & non-weight bearing**

We compared the X-rays of 22 patients who had X-rays both weight bearing and non-weight bearing. We analysed these X-rays to see if there were any differences in TL in these patients. This is demonstrated in *Figure 2*. There was no statistically significant difference between the weight bearing and non-weight bearing status of the patients with P value of 0.6367.

**Antero-posterior & lateral views**

On review of 223 antero-posterior & 258 lateral lumbar radiographs (571 radiographs), the level of Tuffier’s line varied between the body of L3 and the body of L5. It showed a bimodal distribution with peak frequencies at the body of L4 and L5 (*Tables 1,2*). Our study revealed that in

98 patients (186 radiographs, 68%), there was a discrepancy between AP and lateral views in relation to the level of TL.

**Discussion**

There are several studies in the field of anaesthesia demonstrating TL as an inaccurate anatomical landmark with poor inter-observer agreement. TL is a traditionally used anatomical landmark in lumbar spinal surgery, however, there are no studies published in the literature.

We studied a large cohort of 195 patients and 571 radiographs with analysis of line of inter-section of TL and factors influencing it. We found a minor difference in gender specific TL intersection. Horsanali *et al.* (8) found TL can range from the L3 vertebra to the L5 upper vertebra in men, while L3 to lower part of L5 vertebra in women. Our findings indicated that in men, TL often intersects the lower L4 vertebral body followed closely by the L4–5 disc space, whilst in women although TL does most commonly intersect at the L5 vertebral body,

**Table 2** Location of Tuffier's line in the anterior posterior view

| Spinal level         | Overall population (N=194), n, % (95% CI) | Male (N=82), n, % (95% CI) | Female (N=112), n, % (95% CI) |
|----------------------|---|----------------------------|-------------------------------|
| L3 body              | 3, 1.5 (3–4%)                             | 0, 0                       | 3, 2.7 (0–7.6%)               |
| L4 body              | 94, 48.5 (42–55%)                         | 43, 52.4 (41.8–63%)        | 51, 45.5 (36.6–54.8%)         |
| L4 inferior endplate | 4, 2.1 (5.3–6%)                           | 1, 1.2 (0–7%)              | 3, 2.7 (1–9%)                 |
| L4–L5 disk level     | 51, 26.3 (20.6–32.9%)                     | 20, 24.4 (16.3–34.8%)      | 31, 27.7 (19.6–36.9%)         |
| L5 superior endplate | 0, 0                                      | 0, 0                       | 0, 0                          |
| L5 body              | 42, 21.6 (16.4–28%)                       | 18, 22.0 (14.3–32%)        | 24, 21.4 (14.8–30%)           |

n indicates number of subjects; CI, confidence interval.

this is only slightly more common than the L4 body. We found that age did not confer a difference in TL. In 98 of 195 patients, there was a slight discrepancy between AP and lateral views in relation to the level of TL. In 11 of 22 patients, there was a difference of 1 vertebral level between the weight bearing and non-weight bearing positions. In the available evidences, obesity and position of the patient whilst palpating TL have been shown to have an influence (6,9).

With above-mentioned variations in the level of intersection of TL, there is clinical implication of relying on TL in wrong level spinal surgery. A survey investigating spinal surgeon's attitudes towards overall spinal surgery including pre-incision checks, revealed 55% of surgeon who responded would typically palpate the lumbar spine prior to beginning surgery and correctly for the proposed lumbar level for the operation. In a survey reporting pre-level spinal checks amongst spinal surgeons, it was demonstrated 7% of surgeons do not perform pre-incision radiographic checks (7). There is variation in practice from palpation to pre-incision use of intra-operative fluoroscopy. A recent study revealed that the use of additional X-rays prevented wrong level surgery in 27 cases. In 8 cases, X-ray of the superior and inferior margin and further extension of surgery was required (10). This is a minor clinical issue in terms of soft-tissue dissection at the neighbouring levels and returning back to the correct level of lumbar spinal surgery. One should aim to obtain pre-incision radiograph in all microscope assisted lumbar surgery and post-incision level checks should be done in all as confirmatory or further radiographic evaluation if necessary. We believe that over-reliance on palpatory method could pose undue risks and variations in inter-cristal line should be given enough consideration in order to avoid a wrong level surgery.

Our findings indicate that TL alone should not be

used as a pre-incision level check as TL can be affected by age, gender, radiographic views and weight bearing status variably. Vitale *et al.* demonstrated the use of several X-rays can prevent wrong level surgery (11). We stress here that palpatory method for level check without performing pre-incision lateral X-ray should be discouraged.

In summary, we recommend employing pre-incision radiographs in all microscope assisted lumbar spinal procedures to eliminate the clinical variations in inter-cristal line and thereby avoiding anatomical violation of neighbouring normal levels in microscope-assisted lumbar surgery.

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### Footnote

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

*Ethical Statement:* Ethical approval was not required as this was radiology evaluation of previously treated patients. All patient data were anonymised prior to synthesis.

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