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# A Comparative Study of X-Ray and CT-Scan Measurement of Interpedicular Distance in Thoracolumbar Compression Fracture

**Al Anshari[1], Roni Eka Sahputra[2], Muhammad Ade Refdian Menkher[2]**

[1]Orthopaedic and Traumatology Resident, Dr. M. Djamil Hospital, Andalas University, West Sumatera, Indonesia
[2]Orthopaedic Spine Surgeon, Department of Orthopaedic and Traumatology, Dr. M. Djamil Hospital, Andalas University, West Sumatera, Indonesia.

Corresponding Author: Al Anshari

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## ABSTRACT

Interpedicular distance (IPD) is a key radiographic parameter in thoracolumbar compression fracture assessment. While CT scan is the reference standard for spinal morphometry, plain radiography remains the primary imaging modality in resource-limited settings. This study compared IPD measurements from X-ray and CT scan and evaluated their clinical agreement. A retrospective comparative study was conducted on 30 patients with confirmed thoracolumbar compression fractures who underwent both plain radiography and CT scan at Dr. M. Djamil General Hospital, Padang, Indonesia (2023–2024). IPD was measured at three vertebral points (V1, V0, V2) and expressed as a ratio-based IPD index (%). Paired t-test, Pearson correlation, and Bland-Altman analysis were performed. X-ray systematically overestimated absolute IPD compared to CT scan for V1, V0, and V2 (mean overestimation 7.02–8.36%, all $p < 0.001$), with Bland-Altman limits of agreement spanning up to 0.6 cm. The IPD index (%) showed no significant difference between modalities ($p = 0.059$), with strong correlations across all variables ($r = 0.774$–$0.910$, $p < 0.001$) and 96.7% of cases within limits of agreement. Plain X-ray should not replace CT scan for absolute IPD measurement in surgical planning. However, the ratio-based IPD (%) demonstrates excellent inter-modality agreement and represents a valid, practical parameter for fracture severity assessment where CT availability is limited.

***Keywords:*** interpedicular distance; thoracolumbar fracture; plain radiography; computed tomography; health services accessibility

## INTRODUCTION

Among all segments of the vertebral column, the thoracolumbar region sustains a disproportionate share of traumatic injury: published epidemiological data consistently attribute 60–70% of all spinal fractures to this anatomical zone.[1,2] This concentration of injury reflects the distinctive mechanical character of the thoracolumbar junction, which serves as a structural interface between two biomechanically dissimilar spinal segments.[1,2] Among these injuries, compression fractures frequently result from axial loading mechanisms and may lead to vertebral body collapse, spinal canal compromise, and potential neurological deficit, making accurate radiological assessment essential for diagnosis and treatment planning.[3,4]

In acute care environments, conventional X-ray imaging has retained its status as the predominant first-line investigation for suspected thoracolumbar fractures. Its widespread clinical adoption is attributable to three practical advantages: near-ubiquitous availability of radiographic facilities at all healthcare tiers, a cost profile substantially lower than that of cross-sectional alternatives, and an acquisition time brief enough to avoid delaying urgent clinical decision-making.[5] Notwithstanding its clinical utility, the capacity of plain radiography to generate reliable morphometric data is constrained by a series of inherent technical limitations. Measurement fidelity is diminished by geometric distortion inherent to two-dimensional projection imaging, compounded by variability in vertebral angulation relative to the X-ray beam, inconsistencies in positioning technique across acquisitions, and superimposition of adjacent osseous and soft-tissue structures.[6,7] These limitations are particularly relevant when evaluating transverse spinal parameters such as the interpedicular distance (IPD).[8,9]

Computed tomography has progressively established itself as the criterion-standard modality for thoracolumbar trauma imaging.[2,10] The isotropic volumetric datasets generated by modern multidetector CT platforms can be reformatted in any anatomical plane at high spatial resolution, enabling detailed interrogation of bony architecture that is unattainable with conventional projection techniques.[2,10] CT imaging enables detailed visualization of fracture morphology, pedicle integrity, and spinal canal dimensions, allowing more precise and reproducible morphometric assessment compared with plain radiography.[9] Consequently, CT is widely recommended for definitive evaluation of thoracolumbar fractures, especially when surgical planning is considered.[10,11]

Interpedicular distance occupies a central diagnostic role. It denotes the horizontal measurement spanning the medial cortical margins of the bilateral pedicles at any individual vertebral level — a dimension reflecting both the intrinsic bony architecture of the neural arch and any traumatic deformation thereof.[12] Pathological expansion of interpedicular distance beyond normative values indicates outward deviation of the pedicles from their native position, accompanied by corresponding enlargement of the osseous spinal canal lumen - a radiological pattern characteristically produced by compressive and burst-type failure mechanisms affecting the thoracolumbar column.[2,8] Clinical evidence from prior investigations has established that IPD enlargement functions as a statistically meaningful marker of overall injury severity, demonstrating significant associations with the magnitude of canal encroachment by retropulsed bony fragments, disruption of posterior ligamentous and osseous structures, and the probability of neurological compromise at presentation - observations that collectively justify its inclusion as a fracture severity assessment parameter.[1,13]

Traditionally, IPD measurements have been obtained from anteroposterior radiographs as a simple indicator of vertebral instability and canal widening.[11,12] Nevertheless, radiographic IPD measurements are subject to magnification error and limited reproducibility, raising concerns regarding their accuracy when compared with CT-based measurements.[14] CT-based morphometric analysis allows direct measurement of pedicle anatomy and interpedicular width, providing more reliable data for both diagnostic evaluation and surgical decision-making.[9,15]

Despite the routine use of both X-ray and CT scan in the assessment of thoracolumbar compression fractures, comparative studies evaluating the agreement between IPD measurements obtained from these two imaging modalities remain limited.[16] Understanding the degree of concordance between X-ray and CT-derived IPD measurements is clinically important, particularly in settings where CT availability is limited or when follow-up imaging relies primarily on radiographs.[8,17] Therefore, this study aims to compare interpedicular distance measurements obtained from X-ray and CT scan in patients with thoracolumbar compression fractures and to evaluate their potential implications for clinical assessment and imaging strategy.

## MATERIALS & METHODS

### *Study Design*

A retrospective, comparative quantitative study was conducted to evaluate the agreement between interpedicular distance (IPD) measurements obtained from plain anteroposterior (AP) radiography and computed tomography (CT) in patients with thoracolumbar vertebral compression fractures. Medical imaging data were retrieved from the radiographic archive of the Department of Orthopedics and Traumatology, Dr. M. Djamil General Hospital, Padang, Indonesia. The study period covered patients presenting between January 2023 and December 2024.

### *Participants*

Patients were eligible for inclusion if they met the following criteria: aged between 18 and 75 years, had a confirmed diagnosis of thoracolumbar vertebral compression fracture, and had undergone both plain AP radiography and CT imaging of the thoracolumbar spine during the same hospital admission. Patients were excluded from the study if they had pre-existing spinal deformities such as scoliosis or kyphosis, incomplete or technically inadequate imaging records, or a history of prior spinal surgery at the affected vertebral level. A total of 30 patients fulfilling the inclusion criteria were enrolled in the study.

### *Image Acquisition and Measurement*

Each imaging modality was evaluated independently to measure the interpedicular distance at the level of the fractured vertebra. IPD was defined as the transverse distance between the medial cortical borders of the bilateral pedicles at the affected vertebral level. Measurements were obtained from plain AP radiographs and from axial CT reconstructions at the corresponding vertebral level. All measurements were performed digitally using a standardized radiographic measurement application on a calibrated workstation, with automatic magnification correction applied to plain radiographic images. To minimize cross-referencing bias, measurements from each modality were performed independently and in separate sessions.

### Statistical Analysis

Statistical analyses were performed using SPSS (version 26.0, IBM Corp., Armonk, NY, USA). Continuous variables were expressed as means with standard deviations (SD). The agreement between X-ray and CT-derived IPD measurements was assessed using the intraclass correlation coefficient (ICC) with 95% confidence intervals, where ICC values of 0.75 or above were considered indicative of good to excellent reliability. A paired t-test was applied to detect any systematic difference between the two modalities. The strength of linear association was evaluated using Pearson correlation analysis. Bland-Altman analysis was performed to graphically assess the limits of agreement and to identify any proportional bias between the two measurement methods. A p-value of less than 0.05 was considered statistically significant for all analyses.

## RESULT

A total of 30 patients with thoracolumbar compression fractures were included in this study. Fractures were distributed across seven vertebral levels: Thoracal 4 (n = 1), Thoracal 8 (n = 2), Thoracal 11 (n = 1), Thoracal 12 (n = 3), Lumbar 1 (n = 12), Lumbar 2 (n = 8), and Lumbar 3 (n = 3). The majority of fractures occurred at the thoracolumbar junction, with Lumbar 1 being the most frequently affected level, accounting for 40.0% of all cases (12/30). Overall, lumbar-level fractures constituted 76.7% of the sample (23/30), while thoracal-level fractures comprised 23.3% (7/30). All patients underwent both plain X-ray and CT scan imaging, enabling direct paired comparison of interpedicular distance (IPD) measurements across modalities. All measurement variables, superior interpedicular distance (V1), mid-level interpedicular distance (V0), inferior interpedicular distance (V2), and the IPD index (%) are summarized in Table 1.

**Table 1. The interpedicular distance (IPD) measurements comparing X-ray and CT scan modalities (n = 30).**

| Variable | X-ray | | CT Scan | | Mean Difference (X-ray − CT) | % Overestimation | Cases X-ray > CT n (%) |
|---|---|---|---|---|---|---|---|
| | Mean ± SD | Range | Mean ± SD | Range | | | |
| V1 (cm) | 2.158 ± 0.313 | 1.59–2.85 | 2.021 ± 0.298 | 1.50–2.73 | +0.137 | +7.02% | 26/30 (86.7%) |
| V0 (cm) | 2.365 ± 0.365 | 1.60–3.27 | 2.185 ± 0.332 | 1.50–3.14 | +0.179 | +8.36% | 26/30 (86.7%) |
| V2 (cm) | 2.368 ± 0.317 | 1.69–3.31 | 2.202 ± 0.307 | 1.52–3.14 | +0.166 | +7.89% | 26/30 (86.7%) |
| IPD (%) | 99.729 ± 0.396 | 98.72–100.25 | 99.819 ± 0.307 | 99.01–100.21 | −0.090 | −0.09% | 15/30 (50.0%) |

SD, standard deviation; V1, superior interpedicular distance; V0, mid-level interpedicular distance; V2, inferior interpedicular distance; IPD, interpedicular distance index (%). Single values indicate individual cases (n = 1). % Overestimation calculated as [(X-ray − CT) / CT] × 100.

**Table 2. The interpedicular distance measurements stratified by anatomical level.**

| Anatomical Level | n | V1 (cm) | | V0 (cm) | | V2 (cm) | | IPD (%) | |
|---|---|---|---|---|---|---|---|---|---|
| | | X-ray | CT Scan | X-ray | CT Scan | X-ray | CT Scan | X-ray | CT Scan |
| Thoracal 4 | 1 | 1.61 | 1.50 | 1.60 | 1.50 | 1.69 | 1.52 | 100.08 | 100.02 |
| Thoracal 8 | 2 | 1.84 ± 0.04 | 1.65 ± 0.08 | 1.92 ± 0.06 | 1.71 ± 0.13 | 1.90 ± 0.03 | 1.75 ± 0.01 | 99.89 ± 0.11 | 99.99 ± 0.17 |
| Thoracal 11 | 1 | 1.72 | 1.72 | 1.85 | 1.85 | 2.04 | 2.02 | 100.06 | 100.04 |
| Thoracal 12 | 3 | 1.85 ± 0.22 | 1.81 ± 0.25 | 2.20 ± 0.35 | 2.07 ± 0.11 | 2.18 ± 0.23 | 2.21 ± 0.17 | 99.56 ± 0.42 | 99.88 ± 0.13 |
| Lumbar 1 | 12 | 2.20 ± 0.25 | 2.02 ± 0.25 | 2.46 ± 0.27 | 2.25 ± 0.26 | 2.39 ± 0.16 | 2.20 ± 0.17 | 99.56 ± 0.44 | 99.67 ± 0.35 |
| Lumbar 2 | 8 | 2.28 ± 0.20 | 2.12 ± 0.17 | 2.42 ± 0.26 | 2.21 ± 0.19 | 2.49 ± 0.18 | 2.21 ± 0.20 | 99.89 ± 0.33 | 99.90 ± 0.24 |
| Lumbar 3 | 3 | 2.53 ± 0.35 | 2.48 ± 0.23 | 2.73 ± 0.49 | 2.65 ± 0.42 | 2.80 ± 0.51 | 2.78 ± 0.32 | 99.80 ± 0.44 | 99.89 ± 0.46 |

SD, standard deviation; V1, superior interpedicular distance; V0, mid-level interpedicular distance; V2, inferior interpedicular distance; IPD, interpedicular distance index (%). Data presented as mean ± SD for groups with n ≥ 2, or as single values for n = 1. A thin horizontal line separates thoracal from lumbar vertebral levels.

There is a general trend of increasing absolute measurements that was observed from thoracal to lumbar vertebrae, consistent with the known anatomical pattern of increasing vertebral body size in the caudal direction (Table 2). Lumbar 1 demonstrated the highest variability, which may be attributable to the larger sample size at this level (n = 12) as well as its position at the thoracolumbar junction, a biomechanically transitional zone susceptible to compression fractures.

## Comparison of X-ray and CT Scan Measurements

Statistically significant differences were identified for all three absolute measurements (Table 3). For V1, the mean difference of +0.137 cm reached statistical significance ($t = 5.295$, $df = 29$, $p < 0.001$). Similarly, V0 demonstrated the largest mean difference (+0.179 cm) and the most significant result ($t = 6.492$, $df = 29$, $p < 0.001$). V2 also showed a significant difference (mean diff = +0.166 cm; $t = 5.144$, $df = 29$, $p < 0.001$). These results confirm that X-ray systematically overestimates absolute interpedicular distances relative to CT scan, and that this overestimation is statistically significant and not attributable to random measurement error. Importantly, no statistically significant difference was found for the IPD index (%). The mean difference of −0.090% between modalities did not reach significance ($t = −1.968$, $df = 29$, $p = 0.059$), which is above the pre-specified threshold of $p < 0.05$. This result further supports the validity of the IPD (%) as a modality-independent parameter that can be reliably measured using either X-ray or CT scan without significant systematic error.

**Table 3. Paired t-test results comparing X-ray and CT scan measurements of interpedicular distance (n = 30).**

| Variable | Mean Diff (X-ray − CT) | SD of Diff | t-statistic | df | p-value | Significant |
|---|---|---|---|---|---|---|
| V1 (cm) | +0.1370 | 0.1417 | 5.295 | 29 | < 0.001 | Yes |
| V0 (cm) | +0.1793 | 0.1513 | 6.492 | 29 | < 0.001 | Yes |
| V2 (cm) | +0.1657 | 0.1764 | 5.144 | 29 | < 0.001 | Yes |
| IPD (%) | −0.0900 | 0.2505 | −1.968 | 29 | 0.059 | No |

SD, standard deviation of difference; df, degrees of freedom; p-value threshold for significance: < 0.05. V1, superior interpedicular distance; V0, mid-level interpedicular distance; V2, inferior interpedicular distance; IPD, interpedicular distance index (%).

All variables demonstrated statistically significant positive correlations ($p < 0.001$). The strongest correlation was observed for V0 ($r = 0.910$, $r^2 = 0.828$), indicating that 82.8% of the variance in CT scan V0 measurements can be explained by the corresponding X-ray values. V1 ($r = 0.893$, $r^2 = 0.798$) and V2 ($r = 0.841$, $r^2 = 0.707$) also showed strong correlations. The IPD index (%) demonstrated a strong positive correlation ($r = 0.774$, $r^2 = 0.599$), confirming a consistent and predictable relationship between modalities for this ratio-based parameter.

The high correlation coefficients across all variables indicate that X-ray and CT scan measurements rank patients similarly with respect to their interpedicular distances, despite the systematic absolute difference identified by the paired t-test. This suggests that while X-ray tends to overestimate absolute values, it preserves the relative magnitude of interpedicular distances across patients, which may have implications for clinical screening applications.

**Table 4. Pearson correlation between X-ray and CT scan measurements of interpedicular distance (n = 30).**

| Variable | Pearson r | r² | p-value | Interpretation |
|---|---|---|---|---|
| V1 (cm) | 0.893 | 0.798 | < 0.001 | Strong positive correlation |
| V0 (cm) | 0.910 | 0.828 | < 0.001 | Very strong positive correlation |
| V2 (cm) | 0.841 | 0.707 | < 0.001 | Strong positive correlation |
| IPD (%) | 0.774 | 0.599 | < 0.001 | Strong positive correlation |

r, Pearson correlation coefficient; $r^2$, coefficient of determination; $p < 0.001$ for all variables. Correlation strength: $r \geq 0.90$, very strong; $r = 0.70–0.89$, strong; $r = 0.50–0.69$, moderate.

The level of agreement between X-ray and CT scan measurements beyond correlation was performed using Bland-Altman Analysis, by examining the distribution of pairwise differences relative to their means (Table 5). For V1, the mean bias was +0.137 cm (95% CI: 0.086 to 0.188), with limits of agreement (LoA) ranging from −0.141 to +0.415 cm; 93.3% of cases fell within these limits. For V0, the mean bias was +0.179 cm (95% CI: 0.125 to 0.234), with LoA of −0.117 to +0.476 cm; 86.7% of cases fell within the LoA, indicating the widest spread of disagreement among all variables. For V2, the mean bias was +0.166 cm (95% CI: 0.103 to 0.229), with LoA of −0.180 to +0.511 cm; 93.3% of cases fell within the limits.

For the IPD index (%), the mean bias was −0.090% (95% CI: −0.180 to −0.000), with LoA of −0.581 to +0.401%; 96.7% of cases (29/30) fell within these limits. The near-zero bias and narrow limits of agreement for the IPD (%) confirm excellent agreement between modalities for this parameter, further validating its clinical utility as a reliable measurement regardless of the imaging modality employed.

There is also a consistent positive bias for all absolute measurements (V1, V0, V2), indicating systematic overestimation by X-ray. The 95% confidence intervals of the bias for V1, V0, and V2 do not include zero, confirming that this systematic error is statistically significant. Clinicians should therefore exercise caution when using plain X-ray for absolute interpedicular distance measurement, particularly in pre-operative planning where precise dimensions are critical. The IPD (%) index, by contrast, demonstrated negligible bias with a confidence interval that marginally includes zero (−0.180 to −0.000), supporting its use as a modality-independent clinical index.

**Table 5. Bland-Altman analysis of agreement between X-ray and CT scan measurements of interpedicular distance (n = 30).**

| Variable | Mean Diff | SD of Diff | LoA Lower | LoA Upper | 95% CI of Bias | Within LoA |
|---|---|---|---|---|---|---|
| V1 (cm) | +0.137 | 0.142 | −0.141 | +0.415 | 0.086 to 0.188 | 93.3% |
| V0 (cm) | +0.179 | 0.151 | −0.117 | +0.476 | 0.125 to 0.234 | 86.7% |
| V2 (cm) | +0.166 | 0.176 | −0.180 | +0.511 | 0.103 to 0.229 | 93.3% |
| IPD (%) | −0.090 | 0.251 | −0.581 | +0.401 | −0.180 to −0.000 | 96.7% |

LoA, limits of agreement (mean difference ± 1.96 × SD); 95% CI, confidence interval of the mean bias; Within LoA, proportion of cases within the limits of agreement. V1, superior interpedicular distance; V0, mid-level interpedicular distance; V2, inferior interpedicular distance; IPD, interpedicular distance index (%).

## DISCUSSION

This study examined 30 patients with thoracolumbar compression fractures across seven vertebral levels, with the majority of fractures occurring at Lumbar 1 (n = 12, 40.0%), followed by Lumbar 2 (n = 8, 26.7%) and Lumbar 3 (n = 3, 10.0%), as summarized in Table 2. This distribution is consistent with established epidemiological patterns. The T10–L2 vertebral segment - broadly designated the thoracolumbar junction - consistently ranks as the region of highest fracture incidence within the spinal axis across published epidemiological series. This predisposition reflects a fundamental structural mismatch: thoracic spinal mobility is substantially restricted through bony articulation with the rib cage and sternum, whereas the lumbar spine below functions with comparatively unrestricted range of motion. At this mechanical transition point, stress concentration during axial compressive or flexion-distraction loading substantially exceeds that encountered elsewhere along the column.[18,19] A meta-analysis incorporating data from 469 patients similarly identified the thoracolumbar junction as the most common fracture location, with L1 accounting for the highest single-level incidence.[20] The prevalence of Lumbar 1 fractures in the present cohort is thus representative of the broader clinical picture and lends external validity to the sample composition. Furthermore, the radiographic characteristics of burst fractures at this junction, including posterior vertebral height loss, widening of the interpedicular distance, and retropulsion of fragments into the spinal canal[21,22] make

IPD measurement both clinically meaningful and technically feasible on anteroposterior plain radiography.

As shown in Table 1, X-ray measurements consistently yielded higher absolute values than CT scan for all three linear dimensions: V1 (mean 2.158 ± 0.313 cm vs. 2.021 ± 0.298 cm), V0 (2.365 ± 0.365 cm vs. 2.185 ± 0.332 cm), and V2 (2.368 ± 0.317 cm vs. 2.202 ± 0.307 cm), with X-ray exceeding CT in 86.7% of cases across all three variables. This systematic pattern of overestimation is attributable to the well-recognized phenomenon of geometric magnification inherent to projection radiography, whereby the divergent X-ray beam causes structures located at distance from the detector to appear larger than their true anatomical dimensions.[12] The degree of magnification is governed by the ratio of the source-to-image distance to the object-to-image distance (OID), and the posterior thoracolumbar spine, positioned at a substantial depth from the posterior skin surface, is particularly susceptible to this effect.[23] This finding is corroborated by comparable cross-modality discrepancies reported in the spinal imaging literature: a recent study assessing cervical intervertebral disc height across X-ray, MRI, and CT found a mean systematic difference of 1.3 mm between X-ray and CT ($p < 0.001$), recommending CT as the reference standard for structural spinal measurements.[23] In the present study, the V0 measurement demonstrated the largest mean overestimation (+0.179 cm, +8.36%), which may reflect the greater tissue depth encountered at the mid-vertebral level relative to the superior and inferior endplates.

In contrast to the absolute measurements, the IPD index (%), calculated as the ratio of the fractured vertebra's interpedicular distance to the mean of the adjacent levels, showed negligible and non-directional differences between modalities (mean X-ray 99.729 ± 0.396% vs. CT 99.819 ± 0.307%, Table 1). This behavior is mathematically predictable: because the magnification factor equally affects both the numerator and denominator of the IPD ratio, it cancels out in the calculation, rendering the percentage index immune to the systematic bias that affects absolute measurements.[23,24]

The clinical significance of the IPD (%) as a reliable fracture severity index has been established in landmark studies. In a landmark retrospective investigation by Caffaro and Avanzi involving 260 patients with acute thoracolumbar burst fractures, radiographically derived IPD correlated significantly with the degree of spinal canal narrowing quantified on CT ($r = 0.39$; $p < 0.001$). Their cohort-level analysis further demonstrated that the magnitude of IPD percentage increase differed significantly between patients who presented with neurological compromise (mean 24.7 ± 12.6%) and those in whom concurrent laminar fractures were identified (mean 24.6 ± 16.2%) — establishing IPD as a clinically meaningful severity discriminator.[24,25] More recently, a 2024 study in World Neurosurgery involving 103 patients confirmed that increased IPD from axial trauma allows fragment invasion into the spinal canal, producing neurological compression.[12]

The present finding that IPD (%) is equivalent between modalities therefore has direct practical implications. In many healthcare settings across Indonesia and other low- and middle-income countries, CT scan availability remains constrained by cost, infrastructure, and patient condition at presentation.[26] The present study provides evidence-based justification for the use of plain X-ray as a valid modality for IPD (%) measurement without significant loss of diagnostic accuracy, particularly relevant given that plain radiography is widely available at the primary and secondary hospital level, is less costly, and requires shorter acquisition time.[25,26] The practical utility of X-ray-derived IPD (%) in resource-limited settings is therefore supported both by its statistical equivalence to CT-derived values demonstrated here, and by its established correlation with clinically meaningful outcomes including spinal canal narrowing, neurological deficit, and fracture severity as reported in the literature.[12,26]

The paired t-test results (Table 3) provided formal statistical confirmation of the descriptive findings. Statistically significant differences were identified for all three absolute measurements: V1 ($t = 5.295$, $df = 29$, $p < 0.001$), V0 ($t = 6.492$, $df = 29$, $p < 0.001$), and V2 ($t = 5.144$, $df = 29$, $p < 0.001$), while the IPD (%) did not reach statistical significance ($t = -1.968$, $p = 0.059$). These results establish that the overestimation seen in absolute X-ray measurements is systematic and reproducible, not attributable to random error. The absence of a significant difference in IPD (%) further corroborates its status as a modality-independent parameter. It should be noted that while p-values identify the presence of a statistically significant difference, they do not in themselves communicate the magnitude or clinical acceptability of that difference, an important limitation that necessitated the additional analyses described below.

Pearson correlation analysis (Table 4) confirmed strong to very strong positive correlations between X-ray and CT scan for all variables ($p < 0.001$), with V0 yielding the highest coefficient ($r = 0.910$, $r^2 = 0.828$), followed by V1 ($r = 0.893$), V2 ($r = 0.841$), and IPD (%) ($r = 0.774$). These findings indicate that despite the systematic overestimation of absolute values identified by the paired t-test, X-ray measurements maintain a consistent and predictable linear relationship with CT scan across all interpedicular dimensions.[9] The clinical implication is therefore that X-ray may be used to reliably compare relative interpedicular distances between patients, but CT scan remains the reference standard for absolute measurement in surgical planning.[9,12]

From this study, it is further demonstrated a consistent positive bias for all three absolute measurements, with mean bias values of +0.137 cm for V1 (95% CI: 0.086 to 0.188), +0.179 cm for V0 (95% CI: 0.125 to 0.234), and +0.166 cm for V2 (95% CI: 0.103 to 0.229), confirming that X-ray systematically overestimates absolute interpedicular distances relative to CT scan in a statistically and clinically meaningful manner. The upper limits of agreement for V0 and V2 approached 0.5 cm, a margin that carries direct implications for pre-operative planning in thoracolumbar instrumentation.[23,27] Instrumentation outcome data from published series reinforce the clinical stakes of pre-operative morphometric precision: Aigner and colleagues reported that pedicle caliber was a statistically significant determinant of screw malposition risk in patients undergoing thoracolumbar instrumentation, with implants traversing smaller-diameter pedicles demonstrating substantially higher rates of cortical wall violation.[27] These data imply that preoperative dimensional inaccuracies on the order of millimeters may translate directly into inadequate implant-bone purchase or iatrogenic neurological risk.

This position is further supported by He *et al.* (2024) demonstrating that CT-based pedicle assessment, particularly three-dimensional reconstruction had captures true vertebral dimensions more accurately than plain radiography, observed in patients over 60 years of age.[28] In contrast, the IPD (%) demonstrated a negligible mean bias of −0.090% (95% CI: −0.180 to −0.000), with 96.7% of cases falling within the limits of agreement, confirming excellent inter-modality concordance for this index. These findings collectively suggest that while CT scan is indispensable for absolute measurement and surgical planning, the IPD (%) derived from plain X-ray provides a clinically valid and equivalent parameter for fracture severity assessment, particularly in settings where CT availability is limited.[27,28]

Several limitations of this study warrant acknowledgment. The sample size of 30 patients, while sufficient for overall analyses, limits stratified conclusions at individual vertebral levels where some subgroups comprised only one to three cases (Table 2), and future studies with larger level-stratified samples are needed to confirm these findings.[22,23] Patient body habitus was not recorded, despite its known influence on X-ray magnification effect, and intra- and inter-observer reliability were not assessed, limiting conclusions on measurement reproducibility across clinicians.[6,23] Additionally, IPD (%) values were not correlated with neurological outcomes or canal compromise indices, which would have further validated its clinical utility.[12,20] Future prospective studies should address these gaps across varying patient characteristics and fracture morphologies.

## CONCLUSION

This study found that X-ray significantly overestimates absolute interpedicular distances compared to CT scan and cannot be used interchangeably for surgical planning. However, the IPD index (%) demonstrated equivalent values between both modalities, confirming its reliability as a valid parameter for fracture severity assessment regardless of imaging modality. Plain X-ray-derived IPD (%) may therefore serve as a practical alternative in resource-limited clinical settings.

### *Declaration by Authors*

**Ethical Approval:** Approved

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