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Correlation between Image Findings and Neurological Deficits in Lower Lumbar Fractures

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Abstract

Background: Traumatic fractures of the lower lumbar spine (L3–L5) are rare, comprising ten to thirteen percent of thoracolumbar injuries. Their distinct anatomy and lordotic alignment led to unique loading patterns and a higher risk of burst fractures.

Aim of Study: To evaluate the correlation between image findings and neurological deficits in lower lumbar fractures.

Patients and Methods: A retrospective review of our institution's database for the period from July 2018 and July 2024 yielded 50 consecutive patients who had undergone surgery for lower lumbar fractures. There is no origin of any possible selection bias. Cases have been categorized into two groups: those with neurodeficits (ASIA A, B, C, and D) and those with normal neurology (ASIA E), and radiological predictors have been examined among both groups.

Results: Among patients with neurological deficits, road traffic accidents were the predominant trauma mechanism (n=17), while falls from height were more frequent in the non-neurological group (n=12). No significant difference was found in gender distribution (p>0.05). L3 fractures (n=13), posterior ligamentous complex (PLC) injuries (n=14), and epidural hematomas (n=12) were significantly more often in the neurological deficit group (p<0.05). In contrast, L5 fractures were more prevalent in the non-neurological group (n=18 vs. n=2, p<0.05). Insignificant variances have been found with regard to vertical laminar fractures or overall sex distribution among the groups (p>0.05).

Conclusion: Neurological deficits were linked to L3 fractures, PLC injuries, and canal compromise, while sex, trauma mechanism, and laminar fractures showed no significant impact.

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Key Words: *Lower lumbar fractures – Neurological deficits – Posterior ligamentous complex (PLC) injury – Epidural hematoma.*

Introduction

TRAUMATIC fractures of the lower lumbar spine (L3–L5) are rare, comprising about ten to thirteen percent of thoracolumbar (TL) injuries. Compared to the thoracic and TL spinal areas, the lower lumbar spine has distinct biomechanical and anatomical features. The lordotic position of the lower lumbar spine displaces the body's center of gravity posteriorly to the vertebral body, leading to a uniform distribution of axial compression forces and an increased risk of burst fractures **[1]**.

Thoracolumbar fractures (TLFs) are the most prevalent kind of traumatic spinal fractures, comprising sixty to seventy percent of all cases. Numerous categorization systems have been suggested for guiding TLF management decisions throughout the years. The classifications of older TLFs have been determined by the severity of bony injuries, as evidenced via computed tomography (CT) or conventional radiography **[2]**.

Vertebral body fractures are a prevalent condition that are often observed in routine radiological practice. There are two primary kinds of vertebral body fractures: Traumatic and atraumatic. The latter may be further categorized into (1) insufficiency fractures, such as those occurring in cases having osteoporosis, and (2) pathologic fractures resulting from localized bone abnormalities, such as neoplasia **[3]**.

Traumatic low lumbar fractures (LLFs; L3–L5) are rare, constituting about between ten and thirteen percent of thoracolumbar injuries. In comparison to the thoracolumbar junction area (TLJ;

T12–L2), the lower lumbar spine (LLS) exhibits unique anatomical and biomechanical characteristics. Due to the attachment of the iliolumbar ligament, its position inferior to the pelvic brim, and the greater size of the vertebral body, the lumbosacral joint (LLS) exhibits much more stability compared to the thoracolumbar joint (TLJ). Secondly, due to its lordotic curvature, which displaces the center of gravity posteriorly, lower lumbar spine is less prone to damage of the posterior ligamentous complex (PLC) or post-traumatic kyphosis. Third, LLS mostly contributes to lumbar lordosis, and localized kyphosis in this area may markedly impair global sagittal alignment, leading to impairment **[4]**.

The frequency of osteoporotic vertebral compression fractures (OVCF) is gradually easing along with the number of cases presenting with acute and chronic pain and advancing spinal deformities. 1 In cases having OVCF, the fractured vertebrae experience persistent compression and minor dislocation owing to extended activity, leading to continuous irritation of the peripheral spinal nerves and resultant chronic pain **[5]**.

In the management of TL fractures, both non-operative and operative approaches have been well-established in various centers or areas, supported by adequate resources and clinical experience for both intervention modalities. Surgeons within surgical "schools" may reluctant to adopt non-surgical treatment approaches, while non-surgical "schools" may contest the costs and invasiveness associated with surgical procedures. Due to divergent opinions and genuine concern for cases obtaining optimal therapy, surgeons have found it challenging to achieve consensus on treatment plans or to consent to randomization methods **[6]**.

Traumatic spinal injury (TSI), encompassing spinal cord injuries (SCIs)andspinal column fractures, is a significant worldwide contributor to disability and death. The frequency is greater in low- and middle-income countries (LMICs), at 13.69 per 100,000 individuals, compared to high-income countries (HICs), at 8.72 per 100,000 individuals. The majority of cases having TSI need surgical intervention; nevertheless, surgical rates are low in LMICs owing to restricted access to healthcare, insufficient trained staff, financial barriers, inadequate infrastructure and resources, as well as societal and cultural factors **[7]**.

Spinal fractures in cases having neurological deficit are mostly unstable, affecting all three columns of the spine, demanding efficient management in the initial stages **[8]**.

Thoracolumbar burst fractures are prevalent traumatic conditions in spinal surgery, primarily resulting from falls, traffic injuries, and heavy object injuries. The affected population predominantly comprises young adults, which frequently results in short-term labor loss, with certain cases experiencing long-term neurological impairments, thereby imposing significant economic burdens on both families and society **[9]**.

While several investigations have focused on radiological risk factors for neurological deficits in spinal cord injuries or fractures at the thoracolumbar junction, there is a scarcity of research on low and mid lumbar fractures at the cauda equina level. The aim of this research is to elucidate the function of imaging modalities in expecting neurological impairments associated with traumatic lower lumbar fractures (LLFs; L3–L5).

The goal of this research is to assess the association between imaging results and neurological deficits in lower lumbar fractures.

Patients and Methods

Study population: All patients with complete medical records who had undergone surgery for lower lumbar fractures in the time period between July 2018 and July 2024.

Inclusion criteria: Complete medical records and lower lumbar fractures

Exclusion criteria: Severe osteoporosis (T <–2.5), pediatric age group and pathological fractures.

Tools of study:

Methods:

A retrospective review of our institution's database for the period from July 2018 and July 2024 yielded 50 consecutive patients who had undergone surgery for lower lumbar fractures. No source of possible selection bias exists. Cases have been categorized into two groups: Those with neurodeficits (ASIA A, B, C, and D) and those with normal neurological function (ASIA E), and radiological predictors have been examined among both groups.

General demographic information, involvingsex and age were obtained from patient's medical records. Preoperative radiographic assessment was done using three-dimensional computed tomography (CT) and MRI. A baseline clinical evaluation has been conducted. Blood samples have been collected to evaluate total blood count, International Normalized Ratio (INR), kidney and liver functions, and blood glucose concentrations to confirm that all readings were within normal ranges.

The injury level and neurological state upon presentation (American Spinal Injury Association [ASIA] grade) have been recorded. Computed CT scans have been utilized to assess parameters including anterior vertebral body height, posterior vertebral body height, vertebral body height loss, local kyphosis, retropulsion of fracture fragments, and the existence of vertical lamina fractures (Fig. 1). An MRI has been utilized to assess the canal encroachment ratio (CER), ligament disruption, and the existence of an epidural hematoma (Fig. 2).

Fig. (1): Sagittal computed tomography image showing measurement of anterior vertebral height (AVH) and posterior vertebral height (PVH) in addition to loss of vertebral body height.

Fig. (2): Sagittal magnetic resonance imaging T2 weighted images showing L3 burst fracture and canal encroachment ratio.

Computed tomography images for all cases focused on bone tissue, utilizing a mean window width of 2,000 Hounsfield units and a mean window level of 500 Hounsfield units, with axial images having a slice thickness of three millimeters, while coronal and sagittal images were reconstructed at a slice thickness of two millimeters. An MRI has been conducted with a 1.5-T MRI machine.

Local kyphosis (LK) is the angle created between the lines extending along the superior and inferior endplates of the fractured vertebra. Retropulsion of the fracture fragment (RFF) denotes the measurement from the posterosuperior corner of the fractured vertebral body to a tangent line that intersects the posterior inferior corner of the next normal vertebra. The canal encroachment ratio has been determined viadetermining the anteroposterior canal diameter of the fractured vertebra in conjunction with the diameters of the adjacent vertebrae above and below, utilizing midsagittal magnetic resonance imaging.

Statistical analysis:

The information gathered will be systematically organized, tabulated, and analyzed utilizing the Statistical Package for the Social Sciences (SPSS) version 21 (SPSS Inc, Chicago, the United States of America for qualitative information, frequency and percent distributions will be determined. For the quantitative information, the mean, standard deviation, minimum, and maximum will be determined. The independent samples test will be utilized for the comparison of both groups. For all tests, *p*-values below 0.05 have been deemed significant.

Results

Concerning the group with no neurological deficit, the mean age was 37 years old, the mean Anterior vertebral body height (mm) was 15.04. The mean Posterior vertebral body height (mm) was 20.00. The mean Local kyphosis ° was 10.90. The mean Retropulsion of the fracture fragment (mm) was 3.87. The mean Canal encroachment ratio was 31.536%.

Table (1): Radiological characteristics in the examined group.

Mean ± SD	Studied group N=50
Age	34.2±7.8
Anterior vertebral body height (mm)	14.16±1.33
Posterior vertebral body height (mm)	19.54±0.93
Local kyphosis °	11.05±0.29
Retropulsion of the fracture fragment (mm)	4.92±1.2
Canal encroachment ratio%	45.16±15.85

Concerning the group with neurological deficit, the mean age was 30.64 years old, the mean Anterior vertebral body height (mm) was 13.05. The mean Posterior vertebral body height (mm) was 18.95. The mean Local kyphosis ° was 11.25. The mean Retropulsion of the fracture fragment (mm) was 6.25. The mean Canal encroachment ratio was 62.5%. A statistically significant variancehas been observed among both groups concerning Local kyphosis, Posterior vertebral body height and Retropulsion of the fracture fragment as the P-value less than 0.05. A statistically insignificant variance has been observed among both groups concerning Anterior vertebral body height and Canal encroachment ratioas the p-value more than 0.05.

Table (2): Relation between radiological characteristics and neurological deficit.

	Neurological deficit		P-value
	No	Yes	
- Age	37±8.9	30.64±3.9	0.003
- Anterior vertebral body height (mm)	15.04±0.84	13.05±0.95	0.95
- Posterior vertebral body height (mm)	20±0.86	18.95±0.65	0.041
- Local kyphosis °	10.9±0.2	11.25±0.26	<0.001
- Retropulsion of the fracture fragment (mm)	3.87±0.09	6.25±0.26	<0.001
- Canal encroachment ratio	31.54%±3.62%	62.50%±2.56%	0.181

The mechanism of trauma in the group with neurological deficit was falling from height in 5 patients and road traffic accident in 17 patients. The mechanism of trauma in the group with no neurological deficit was falling from height in 12 patients and road traffic accident in 16 patients. The number of males in the group with neurological deficit was 19. The number of men in the group with no neurological deficit was 25.

Table (3): Relation between mechanism and neurological deficit.

	Neurological deficit	
	No	Yes
FFH	12 (42.9%)	5 (22.7%)
RTA	16 (57.1%)	17 (77.3%)

The number of patients with L3 fracture was 13, with L4 fracture was 7 and with L5 fracture was 2 in the group with neurological deficit. The number of patients with L4 fracture was 10 and with L5 fracture was 18 in the group with no neurological deficit. A statistically significant variance has been observed among both groups as the p-value was under 0.05.

Table (4): Relation between Level of injury and neurological deficit.

	Neurological deficit		P-value
	No	Yes	
L3	0 (0%)	13 (59.1%)	<0.001
L4	10 (35.7%)	7 (31.8%)	
L5	18 (64.3%)	2 (9.1%)	

The number of cases having PLC injury was 14 in the group with neurological deficit. The number of cases having PLC injury was 10 in the group with no neurological deficit. A statistically significant variance has been observed among both groups as the p-value was under 0.05.

Table (5): Relation between PLC injury and Neurological deficit.

	Neurological deficit		P-value
	No	Yes	
No	18 (64.3%)	8 (36.4%)	0.05
Yes	10 (35.7%)	14 (63.6%)	

The number of caseshaving vertical laminar fracture was 15 in the group with neurological deficit. The number of cases having vertical laminar fracture was 14 in the group with no neurological deficit. A statistically insignificant distinction has been observed among both groups as the P-value was above 0.05.

Table (6): Relation between Vertical lamina fracture and Neurological deficit.

	Neurological deficit		P-value
	No	Yes	
No	14 (50%)	7 (31.8%)	0.196
Yes	14 (50%)	15 (68.2%)	

The number of cases having epidural hematoma was 12 in the group with neurological deficit. The number of cases having epidural hematoma was 2 in the group with no neurological deficit. A statistically significant distinction has been observed among both groups as the *p*-value was under 0.05.

Table (7): Relation between Epidural hematoma and Neurological deficit.

	Neurological deficit		*p*-value
	No	Yes	
No	26 (92.9%)	10 (45.5%)	<0.001
Yes	2 (7.1%)	12 (54.5%)	

The number of women was 3 in the group with neurological deficit. The number of women was 3 in the group with no neurological deficit. The number of men was 19 in the group with neurological deficit. The number of Men was 25 in the group with no neurological deficit. A statistically Insignificant variance has been observed among both groups as the *p*-value was above 0.05.

Table (8): Relation between sex and Neurological deficit.

	Neurological deficit		*p*-value
	No	Yes	
Female	3 (10.7%)	3 (13.6%)	0.752
Male	25 (89.3%)	19 (86.4%)	

Discussion

A retrospective review of our institution's database for the period from July 2018 and July 2024 yielded 50 consecutive patients who had undergone surgery for lower lumbar fractures. No source for possible selection bias exists. Cases have been categorized into two groups: those with neurodeficits (ASIA A, B, C, and D) and those with normal neurological function (ASIA E), and radiological predictors have been examined among both groups.

Findings showed that the group with no neurological deficit had a mean age of 37 years old, the mean anterior vertebral body height (mm) was 15.04. The mean posterior vertebral body height (mm) was 20.00. The mean Local kyphosis ° was 10.90. The mean Retropulsion of the fracture fragment (mm) was 3.87. The mean Canal encroachment ratio was 31.536%.

Similar to Park et al. *[10]*, who assessed the frequency of dural tears in cases having lumbar burst fractures accompanied by vertical laminar fractures aiming to ascertain if radiographic and clinical factors may expect the occurrence of dural tears.

Their study included 31 patients, the mean age was 37 years old. The mean local kyphosis ° was 47.5±14.7. The mean retropulsion of the fracture fragment (mm) was 37.2±13.1. The mean canal encroachment ratio was 61.9±17.0.

Regarding relation between mechanism and neurological deficit findings showed that the mechanism of trauma in the group with neurological deficit was falling from height in 5 patients and road traffic accident in 17 patients. The mechanism of trauma in the group with no neurological deficit was falling from height in 12 patients and road traffic accident in 16 patients. The number of men in the group with neurological deficit was 19. The number of men in the group with no neurological deficit was 25. A statistically insignificant variance was observed among both groups as the *p*-value was above 0.05.

In concordance with Ramachandran and Shetty, et al. *[11]*, who evaluated the diagnostic accuracy of integrated CT results for identifying posterior ligamentous complex PLC injury in cases having lower lumbar fractures, conducted on 108 cases. Their study reported that the mechanism of trauma in the group with neurological deficit was falling from height in 59 (54.6) patients and road traffic accident in 23 (21.3) patients. The number of men in the group with PLC injury was 51 (89.5). The number of men in the group with no PLC injurywas 45 (88.2). A statistically insignificant variance has been observed among both groups as the *p*-value was above 0.05.

Also, our results agreed with Ramachandran and Iyer, et al. *[1]* who understood the role of MRI in expecting neurological deficits in traumatic lower lumbar fractures (LLFs; L3–L5), included 108 patients. Their study found that the mechanism of trauma in the group with neurological deficit was falling from height in 9 (17.6) patients and road traffic accident in 33 (64.7) patients. The mechanism of trauma in the group with no neurological deficit was falling from height in 14 (24.6) patients and road traffic accident in 27 (47.4) patients. The number of men in the group with neurological deficit was 45 (88.2). The number of men in the group with no neurological deficit was 51 (89.5). A statistically insignificant variance has been observed among both groups as the *p*-value was more than 0.05.

Regarding relation between level of injury and neurological deficit, findings showed that the number of patients with L3 fracture was 35, with L4 fracture was 15 and with L5 fracture was 1 in the group with neurological deficit. The number of patients with L3 fracture was 36, with L4 fracture was 19 and with L5 fracture was 2 in the group with no neurological deficit. A statistically insignificant distinction has been observed among both groups as the p-value was more than 0.05.

In line with Ramachandran and Shetty, et al. [11] Their study reported that the number of patients with L3 fracture was 37 (64.9), with L4 fracture was 18 (31.6) and with L5 fracture was 2 (3.5) in the group with PLC injury. The number of patients with L3 fracture was 34 (66.7), with L4 fracture was 16 (31.4), and with L5 fracture was 1 (1.9) in the group with no PLC injury.

In agreement with Ramachandran, Iyer, et al. [1] Their study reported that the number of patients with L3 fracture was 35 (68.6), with L4 fracture was 15 (29.4) and with L5 fracture was 1 (2) in the group with neurological deficit. The number of patients with L3 fracture 36 (63.2), with L4 fracture was 19 (33.3) and with L5 fracture was 2 (3.5) in the group with no neurological deficit. A statistically insignificant variance has been observed amongboth groups as the p-value was more than 0.05.

In contrast with Park et al. [10] Their study reported that the number of patients with L3 fracture was 1, with L4 fracture was 2 and with L5 fracture was 0 in the group with dural tear. The number of patients with L3 fracture was 1, with L4 fracture was 0 and with L5 fracture was 1 in the group with no dural tear. There was no statistically significant difference between the two groups as the p-value was more than 0.05.

Regarding relation between PLC injury and Neurological deficit findings showed that the number of patients with PLC injury was 14 in the group with neurological deficit. The number of patients with PLC injury was 10 in the group with no neurological deficit. There was statistically significant difference between the two groups as the p-value was less than 0.05.

In agreement with Ramachandran and Iyer, et al. [1] Their study reported that the number of patients with PLC injury was 30 (58.8) in the group with neurological deficit. The number of cases with PLC injury was 27 (47.4) in the group with no neurological deficit. A statistically insignificant variance has been observed among both groups as the p-value more than 0.05.

In consistent with de Azevedo et al. [12] who expedited the clinical decision through assessing the diagnostic value of computed tomography parameters and creating a reproducible score utilizing combined CT parameters in the diagnosis of nonobvious PLC injury, included 154 cases. Their study found that the number of cases with PLC injury was 37 (24.0%) in the group with neurological deficit. The number of patients with PLC injury was 12 (7.8%) in the group with no neurological deficit. A statistically significant distinction has been observed among both groups as the p-value was under 0.05.

Regarding relation between Vertical lamina fracture and Neurological deficit, findings showed that the number of caseshaving vertical laminar fracture was 15 in the group with neurological deficit. The number of cases having vertical laminar fracture was 14 in the group with no neurological deficit. A statistically insignificant variancehas been observed among both groups as the p-value was above 0.05.

In agreement with Ramachandran and Iyer, et al. [1] Their study found that the number of cases having vertical laminar fracture was 35 (68.6) in the group with neurological deficit. The number of cases having vertical laminar fracture was 29 (50.9) in the group with no neurological deficit. A statistically insignificant variancehas been observed among both groups as the p-value was above 0.05.

Regarding relation between sex and Neurological deficit findings showed that the number of Women was 3 in the group with neurological deficit. The number of women was 3 in the group with no neurological deficit. The number of men was 25 in the group with neurological deficit. The number of Men was 19 in the group with no neurological deficit. A statistically insignificant variancehas been observed among both groups as the p-value was above 0.05.

In agreement with Germann et al. [3] who validated the performance of a deep convolutional neural network (DCNN) for vertebral body measurements and insufficiency fracture recognition on lumbar spine magnetic resonance image, involved 1000 vertebral body fractures in 200 patients. Their study found that the number of women was 108 (67.5) in the group with neurological deficit. The number of women was 17 (42.5) in the group with no neurological deficit. The number of men was 52 (32.5) in the group with neurological deficit. The number of Men was 23 (57.5) in the group with no neurological deficit. A statistically insignificant variance has been observed amongboth groups as the p-value was more than 0.05.

Conclusion:

The current investigation found that neurological deficits in lumbar spine trauma were significantly associated with L3 fractures, posterior ligamentous complex (PLC) injuries, and greater canal encroachment and retropulsion. In contrast, mechanism of injury, sex, and presence of vertical laminar fractures didn't illustrate a significant variance among groups. These findings highlight the importance of radiological assessment particularly fracture level, canal compromise, and PLC integrity in predicting neurological outcomes.

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العلاقة بين نتائج الصور والعجز العصبى فى كسور أسفل الظهر

تعُد الكسور الرضحية فى أسفل العمود الفقرى القطنى (الفقرة الثالثة والرابعة والخامسة) نادرة، إذ تشُكل ما بين ١٠٪ و١٣٪ من إصابات الفقرات الصدرية القطنية. وقد أدى تشريحها المميز ومحاذاة الفقرات القطنية إلى أنماط تحميل فريدة وزيادة خطر الإصابة بالكسور الانفجارية، تهدف الدراسة لتقييم العلاقة بين نتائج الصور والعجز العصبى فى كسور أسفل الظهر، أظهر مراجعة استعادية لقاعدة بيانات مؤسستنا للفترة من يوليو ٢٠١٨ إلى يوليو ٢٠٢٤ خضوع ٥٠ مريضاً متتالياً لجراحة كسور أسفل الظهر. ولم يُعثر على أى تحيز محتمل فى الاختيار. صُنفت الحالات إلى مجموعتين: حالات تعانى من عيوب عصبية وحالات عصبية طبيعية، وخضعت كلتا المجموعتين للفحص الإشعاعى، بين المرضى الذين يعانون من عجز عصبى، كانت حوادث المرور الآلية السائدة للصادمة عددها ١٧، بينما كان السقوط من ارتفاع أكثر شيوعاً فى المجموعة غير العصبية عددها ١٢. لم يُعثر على فرق كبير فى توزيع الجنسين، كانت كسور الفقرة القطنية الثالثة عددها ١٣، وإصابات مجمع الرباط الخلفى عددها ١٤، والأورام الدموية فوق الجافية عددها ١٢، أكثر شيوعاً بشكل ملحوظ فى مجموعة العجز العصبى، فى المقابل، كان كسور الفقرة القطنية الخامسة أكثر شيوعاً فى المجموعة غير العصبية عددها ١٨، وُجدت فروق طفيفة فيما يتعلق بالكسور الصفيحية العمودية أو التوزيع العام للجنس بين المجموعات، ارتبط العجز العصبي بكسور الفقرة القطنية الثالثة، وإصابات القناة الشوكية، وتضرر القناة، فى حين لم يظهر الجنس، وآلية الصدمة، والكسور الصفائحية أى تأثير كبير.