

## Is a Fracture of the Transverse Process of L5 an Indicator of the Presence and/or Severity of a Pelvic Fracture?

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### Abstract:

**Introduction:** A transverse process of L5 (L5TP) fracture may be associated with the presence and/or severity of a pelvic fracture. However, there is little evidence to support this view. The purpose of this study was to investigate the relationship between L5 TP fracture and the presence and/or severity of a pelvic fracture on radiograph and CT.

**Methods:** A total of 146 patients (82 women and 64 men; age range, 5-97 years) who were treated for pelvic fractures were evaluated. The site of pelvic fractures, presence of an L5 TP fracture with radiograph and CT, associated injuries and the need for blood transfusion, surgical intervention, and mortality were investigated retrospectively. According to the Burgess and Young classification, there were 42 unstable fractures. For each parameter, correlations between the parameters were evaluated using a chi-squared test and a logistic regression analysis. A p-value <0.05 was considered to be statistically significant.

**Results:** The sensitivity of L5 TP fractures on radiograph and CT were 51% and 95%, respectively (p < 0.0001). Multiple logistic regression analysis revealed that, of the L5 TP fractures patients on radiograph, the odds ratios for sacral fractures were 4.5 (95% confident interval [CI], 1.1-17.9); based on CT, the odds ratios for sacral fractures and the need for blood transfusion were 18.2 (95%CI, 5.1-64.9) and 3.2 (95%CI, 1.1-9.1), respectively.

**Conclusions:** This study demonstrated that L5 TP fractures on radiograph and/or CT could indicate a high risk of sacral fracture and need for blood transfusion.

When an L5TP fracture is diagnosed on initial radiograph or CT in the emergency setting, it is necessary to conduct further investigations for pelvic ring fractures and to alert the attending staff to the high-risk fracture.

### Keywords:

L5 transverse process fracture, pelvic fracture, unstable pelvic fracture, Hemodynamic instability

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### Introduction

Pelvic fractures are associated with significant mortality, ranging from 5% to 40% in the literature<sup>1-6)</sup>. Hemodynamic instability and multiple organ failure as direct consequences of pelvic hemorrhaging have been identified as the primary causes of death following pelvic fracture<sup>3)</sup>. Therefore, the early recognition and prompt treatment of unstable hemodynamic conditions associated with severe pelvic fractures can improve patient outcomes. Although fractures of the transverse process of L5 (L5 TP) are commonly thought to be

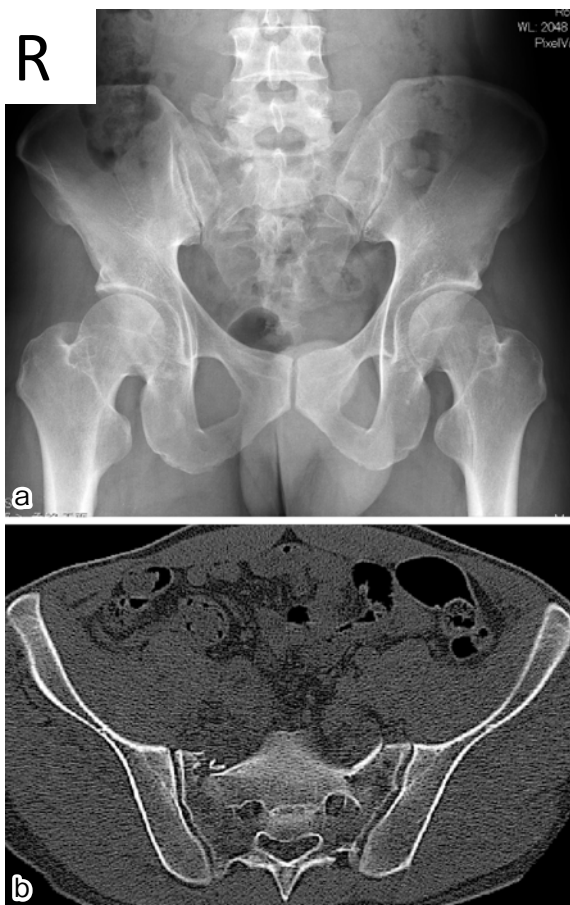
minor injuries compared with fractures of the spinal body, several authors have reported that an L5 TP fracture may be associated with the presence and/or severity of a pelvic fracture, and other organ injuries<sup>7-11)</sup>. However, Nasef et al.<sup>12)</sup> failed to identify a relationship between L5 TP fractures and the stability of the pelvic ring in a recent meta-analysis.

When suspicion is raised concerning a pelvic fracture from a high-energy injury, the standard first trauma radiograph is an anteroposterior view of the pelvis in the emergency setting. Although the pelvic ring may be displaced at the time of the injury, pelvic fracture may be reduced by the

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**Figure 1.** A 42-year-old man with low back pain due to fall from height. (a) Anteroposterior X-ray of the pelvis. (b) Pelvic CT. Anteroposterior X-ray of the pelvis (a) showed right L5 TP fracture but no sacral fracture. Pelvic CT (b) demonstrated sacral alar.

prehospital use of pelvic binders.

Since this situation can make the presence of pelvic fracture less apparent radiologically, the identification of an L5 TP fracture on a plain radiograph may be an indicator of pelvic fractures (Fig. 1). However, there is little evidence of this. In previous reports concerning the association between an L5 TP fracture and pelvic fractures, the diagnosis of L5 TP fracture was evaluated mostly using computed tomography (CT)<sup>7-11</sup> (Tables 1, 2).

Thus, the association between L5 TP fracture on plain radiography and pelvic fractures remains unclear, as do the characteristics of L5 TP pelvic fractures on radiography and CT. The objective of this study was to investigate the association between L5 TP fracture and the presence and severity of pelvic fractures on radiography and CT.

## Materials and Methods

A total of 146 consecutive patients who were treated for pelvic fractures from 2009 to 2013 were identified from 3 hospitals' trauma databases: Saga University Hospital, Karatsu Red Cross Hospital, and Ureshino Medical Hospital. There were 82 women and 64 men with a mean age of 60

years (5 to 97). This study was approved by the institutional ethics committee of all three hospitals. Every patient had an anteroposterior view of the chest and pelvis as well as a CT scan of the head, chest, abdomen, and pelvis obtained on admission. The patient demographics, site of pelvic fracture, presence of an L5 TP fracture on radiography and CT, associated injuries and need for blood transfusion or surgical intervention, as well as mortality were investigated retrospectively. Sites of pelvic fractures were diagnosed based on both radiographs and CT of the pelvis.

According to the Burgess and Young classification<sup>13</sup>, the pelvic fractures were divided into stable type (lateral compression [LC]1, LC2, and anterior posterior compression [APC]1) and unstable type (LC3, APC2, APC3 and vertical shear [VS]).

Associated injuries were classified into head, chest, intra-abdominal, long bone fracture, and spinal fracture. Head trauma was defined as fracture of the skull or intracranial injury. Chest trauma was defined as fracture of the thorax bones, pneumo-hemothorax, injury to heart and lung. Intra-abdominal trauma was defined as injury to the gastrointestinal tract, liver, spleen, and kidney. Surgical intervention was defined as trans-artery embolism, or external and/or internal fixation of the pelvis.

The data were analyzed using the chi-square test. The odds ratios for an L5 TP fracture on radiography and CT as an indicator of the severity of pelvic fractures, including associated injuries, were calculated. A p-value <0.05 was considered to be statistically significant.

## Results

### *Mechanism of injuries and associated injuries*

The causes of injury were road traffic injury (47%, n = 68), fall from height (45%, n = 66), crushing (workplace accident) (5%, n = 7) and fall from standing (3%, n = 5).

Most pelvic fractures were the result of high-energy trauma, such as a traffic accident or a fall from a height. In all, there were 42 (29%) unstable fractures, and 100 patients (68%) had associated injuries. Among those enrolled in the study, the prevalence of the associated injuries was as follows: head trauma, 21%, n = 30; chest injury, 33%, n = 48; intra-abdominal trauma, 15%, n = 22; long bone fracture, 38%, n = 56; and spinal fracture, 18%, n = 26. The most common associated injuries were to the chest and fractures of long bones.

### *Radiography vs. CT in detecting L5 TP fracture*

Among all patients, CT identified 37 of 39 L5 TP fractures (95%), whereas radiography detected 20 of 39 L5 TP fractures (51%). Only 2 patients (2%) had an L5 TP fracture that was detected on radiography but not CT.

In contrast, 21 L5 TP fractures (54%) were identified on CT but overlooked on radiography because of a poor image quality, excessive bowel gas, fecal material, or artifacts, even

**Table 1.** Characteristics of Previous Reports.

Author, Year	Total	study design	Age (years; mean [range])	Male/female	Device used to diagnose L5TP fracture	Mechanism
Reis <sup>7)</sup> , 1985	5	retrospective	31 (22-45)	3/2	Plain Radiograph	20% TA 60% FFH
Starks <sup>8)</sup> , 2011	80	retrospective	40 (10-96)	48/32	CT	58.7% TA 13.7% FFH
Chmelova <sup>10)</sup> , 2011	106	retrospective	43 (16-95)	68/38	Plain Radiograph, CT	NA
Maqungo <sup>11)</sup> , 2015	54	retrospective	NA	NA	CT	77% TA 20% FFH
Our study	146	retrospective	60 (5-97)	82/64	Plain Radiograph	47% TA 45% FFH

TA: traffic accident; FFH: fall from height; TP: transverse process

**Table 2.** Overview of Reports.

Author, Year	Total	Device used to diagnose L5TP fracture	Stable fracture	Unstable fracture	Conclusion/comments
			L5TP/no L5TP	L5TP/no L5TP	
Reis <sup>7)</sup> , 1985	5	Radiograph	4/0	1/0	L5 TP fracture may be the only radiological sign of pelvic instability in cases of posterior pelvic injury.
Starks <sup>8)</sup> , 2011	80	CT	3/42	14/21	L5 TP fracture is highly associated with an unstable pelvic fracture pattern.
Chmelova <sup>10)</sup> , 2011	106	Radiograph, CT	0/22	21/63	L5 TP fracture is highly associated with an unstable pelvic fracture pattern.
Maqungo <sup>11)</sup> , 2015	54	CT	7/21	5/21	The presence of L5 TP fracture strongly indicates an underlying pelvic ring fracture (p=0.001); however, it does not indicate an unstable pattern of pelvic ring fracture.
Our study	146	Radiograph CT	10/94 11/93	10/32 16/26	L5 TP fractures on radiograph and/or may be regarded as an indicator of the severity of pelvic fracture in relation to the unstable fracture. However, a multiple regression analysis revealed that L5 TP fractures on radiograph and/or CT indicate sacral fracture, not an unstable fracture.

with the knowledge that fractures were present. The p-value was <0.0001, showing that CT was more sensitive for finding L5 fractures than radiography.

**The comparison of various parameters with and without an L5 TP fracture based on both radiograph and CT**

Results of the comparison between L5 TP fracture and no-L5 TP fracture are shown in Tables 3, 4. Based on either radiograph or CT, patients in the L5 TP fracture group had a significantly higher rate of unstable fracture; fracture of the sacrum, pubis, and ischium; need for blood transfusion; and need for surgical intervention than patients in the no-L5 TP fracture group. Furthermore, on CT only, patients in the L5 TP fracture group had a significantly higher mortality rate than those in the no-L5 TP fracture group (Table 3, 4).

A multiple logistic regression analysis was performed (Table 5). Of the L5 TP fractures detected on radiography, the odds ratio for sacral fractures in the L5TP fracture group compared with the non-L5 TP fracture was 4.5 (95% confidence interval [CI], 1.1-17.9). Based on CT findings, the odds ratios for sacral fractures and the need for blood trans-

fusion compared with non-L5 TP fracture were 18.2 (95% CI, 5.1-64.9) and 3.2 (95% CI, 1.1-9.1), respectively.

**Discussion**

A pelvic ring fracture is a high-energy injury and should be suspected in any patient whose history includes a suggestive mechanism (motor vehicle accident, crush injury, or fall from a height). When a pelvic fracture due to a high-energy injury is suspected, the standard first trauma radiograph is an anteroposterior view of the pelvis in the emergency setting. However, the present retrospective study showed that radiography detected only 51% of L5 TP fractures even with the knowledge that fractures had been detected on CT. This suggests that the presence of L5 TP fracture on initial radiographs may be underestimated or missed because of a poor image quality due to bowel gas or fecal material<sup>14-16)</sup>.

Although the sensitivity of radiography for detecting L5 TP fractures was not high, an L5 TP fracture detected on radiography may be regarded as an indicator of the severity of the pelvic fracture in relation to the unstable fracture; the

**Table 3.** Parameters with and without an L5 TP Fracture Based on Radiograph Findings.

	L5 TP fracture	No-L5 TP fracture	P value
	(n=20)	(n=126)	
Unstable fracture	10 (50%)	32 (25%)	0.024
Pelvic fracture			
Sacrum	16 (80%)	45 (36%)	p<0.0001
Ileum	7 (35%)	63 (50%)	0.212
Pubis and/or ischium	18 (90%)	83 (66%)	0.03
Acetabulum	4 (20%)	40 (32%)	0.288
Associated injuries			
Head	6 (30%)	24 (19%)	0.26
Chest	7 (35%)	41 (33%)	0.934
Intra-abdominal	3 (15%)	19 (15%)	0.933
Long bone fracture	8 (40%)	48 (38%)	0.871
Spinal fracture	3 (15%)	23 (18%)	0.724
Need for blood transfusion	13 (65%)	40 (32%)	0.0004
Need for surgical intervention	8 (40%)	16 (13%)	0.045
Mortality rate	3 (15%)	12 (10%)	0.454

**Table 4.** Parameters with and without an L5 TP Fracture Based on CT Findings.

	L5 TP fracture	No-L5 TP fracture	P value
	(n=37)	(n=109)	
Unstable fracture	16 (51%)	26 (24%)	0.024
Pelvic fracture			
Sacrum	32 (86%)	29 (27%)	p<0.0001
Ileum	13 (35%)	57 (52%)	0.071
Pubis and/or ischium	33 (89%)	68 (62%)	0.002
acetabulum	5 (14%)	39 (36%)	0.069
Associated injuries			
Head	11 (30%)	20 (18%)	0.259
Chest	15 (41%)	33 (30%)	0.251
Intra-abdominal	9 (24%)	13 (12%)	0.069
Long bone fracture	11 (30%)	45 (41%)	0.212
Spinal fracture	10 (27%)	15 (14%)	0.064
Need for blood transfusion	23 (62%)	30 (28%)	p<0.0001
Need for surgical intervention	9 (24%)	12 (11%)	0.046
Mortality rate	7 (19%)	8 (7%)	0.046

likelihood of fracture of the sacrum, pubis, or ischium; need for blood transfusion; need for surgical intervention compared with the no-L5 TP fracture group (Table 3). These findings suggest that, if an L5 TP fracture is diagnosed on initial radiograph in the emergency setting, it is necessary to conduct further investigations for pelvic ring fractures using CT and to alert the attending staff to the presence of a high-risk fracture. Our results based on both radiography and CT are similar to those of previous reports (Table 2).

As indicated by the odds ratio shown in the regression analysis, an L5 TP fracture based on either radiograph or CT may be regarded as an indicator of a fracture of the sacrum compared to patients with no L5 TP fracture. In patients with and without L5 TP fracture on radiography, 80% and 36% had sacral fractures, respectively ( $p < 0.0001$ ). In patients with and without L5 TP fracture on CT, 86% and

27% had sacral fractures, respectively ( $p < 0.0001$ ). Frequently these fractures are radiographically occult and, in particular, sacrum fractures are relatively underdiagnosed<sup>17,18</sup>. The entire pelvis should be imaged on CT or magnetic resonance imaging in patients found to have L5 TP fractures on radiography, and a careful search for concomitant fractures is always warranted.

In addition, the presence of an L5 TP fracture on CT was associated with the need for blood transfusion. Although the decision to perform blood transfusion was dependent on the emergency department doctor, blood transfusion was required in order to hemodynamically stabilize patients with hypotension, i.e. systolic blood pressure  $<80$  mmHg. Because the major cause of death in patients with pelvic fracture is hemorrhaging, hemodynamic and temporary skeletal stabilization are important at the initial treatment<sup>1-6</sup>. There-

**Table 5.** Results of a Logistic Regression Analysis of the L5 TP Fracture: Radiograph vs. CT.

	Radiograph		CT	
	Odds ratio (95% CI)	P value	Odds ratio (95% CI)	P value
Unstable fracture	1.2 (0.4-3.9)	0.8	0.5 (0.2-1.6)	0.24
Pelvic fracture				
Sacrum	4.5 (1.1-17.9)	0.034	18.2 (5.1-64.9)	P<0.0001
Pubis and ischium	1.7 (0.3-0.8)	0.57	1.0 (0.2-4.4)	0.99
Need for blood transfusion	2.4 (0.8-7.8)	0.13	3.2 (1.1-9.1)	0.03
Need for surgical intervention	1.3 (0.3-4.8)	0.71	0.8 (0.2-3.0)	0.79
Mortality rate	0.6 (0.1-2.6)	0.47	1.3 (0.3-4.9)	0.74

fore, the early recognition of the need for transfusion may help guide both immediate and long-term treatment and ultimately could reduce morbidity and mortality. Our findings suggest that an assessment for L5 TP fracture on CT would be useful for the prediction of significant hypotension.

Several limitations associated with the present study must be noted. First, this was a retrospective, cross-sectional study. Second, the present study showed that L5 TP fractures on radiography and CT were associated with multiple parameters. However, a multiple regression analysis revealed that L5 TP fractures on radiography and CT were only significantly associated with sacral fracture and the need for blood transfusion; L5 TP fractures on radiography and CT did not indicate unstable pelvic fracture or the need for surgical intervention.

Of note, several authors have previously reported that L5 TP fracture is associated with unstable pelvic fracture<sup>7-11</sup>. However, most of those reports involved a small sample size, and the authors did not perform a multiple regression analysis. Our results are in line with those of the recent meta-analysis of Nasef et al.<sup>12</sup> detecting no relationship between L5 TP fractures and unstable pelvic fracture. A prospectively designed large-scale study would be more informative for revealing the related influential factors, particularly unstable pelvic fracture.

In summary, we showed that L5 TP fractures on radiography and CT indicated a high risk of sacral fracture and the need for blood transfusion. When an L5 TP fracture is diagnosed on initial radiograph or CT in the emergency setting, it is necessary to conduct further investigations for pelvic ring fractures and to alert the attending staff to the presence of a high-risk fracture.

**Conflicts of Interest:** The authors declare that there are no relevant conflicts of interest.

**Author Contributions:** Tadatsugu Morimoto wrote and prepared the manuscript, Motoki Sonohata participated in writing or technical editing of the manuscript, Makoto Shiraki, Kenji Ogawa, and Ko Ikuta collected data, Masaaki Mawatari served as scientific advisors.

**Informed Consent (for clinical correspondence only):**

This study is a retrospective observational study carried out using the opt-out method via our hospital website.

## References

- Demetriades D, Karaiskakis M, Toutouzas K, et al. Pelvic fractures: epidemiology and predictors of associated abdominal injuries and outcomes. *J Am Coll Surg.* 2002;195(1):1-10.
- McCormack R, Strauss EJ, Alwattar BJ, et al. Diagnosis and management of pelvic fractures. *Bull NYU Hosp Jt Dis.* 2010;68(4):281-91.
- Poole GV, Ward EF. Causes of mortality in patients with pelvic fractures. *Orthopedics.* 1994;17(8):691-6.
- Smith W, Williams A, Agudelo J, et al. Early predictors of mortality in hemodynamically unstable pelvis fractures. *J Orthop Trauma.* 2007;21(1):31-7.
- Starr AJ, Griffin DR, Reinert CM, et al. Pelvic ring disruptions: prediction of associated injuries, transfusion requirement, pelvic arteriography, complications, and mortality. *J Orthop Trauma.* 2002;16(8):553-61.
- White CE, Hsu WJ, Holcomb JB. Haemodynamically unstable pelvic fractures. *Injury.* 2009;40(10):1023-30.
- Reis ND, Keret D. Fracture of the transverse process of the fifth lumbar vertebra. *Injury.* 1985;16(6):421-3.
- Starks IA, Frost A, Wall P, et al. Is a fracture of the transverse process of L5 a predictor of pelvic fracture instability? *J Bone Joint Surg.* 2011;93(7):967-9.
- Tile M. Pelvic ring fractures: should they be fixed? *J Bone Joint Surg.* 1988;70(1):1-12.
- Chmelová J, Džupa V, Procházka B, et al. Fractures of the L5 transverse process in pelvic ring injury. *Acta Chir Orthop Traumatol Cechoslov.* 2011;78(1):46-8.
- Maqungo S, Kimani M, Chhiba D, et al. The L5 transverse process fracture revisited. Does its presence predict the pelvis fracture instability? *Injury.* 2015;46(8):1629-30.
- Nasef H, Elhessy A, Abushaban F, et al. Pelvic fracture instability-associated L5 transverse process fracture, fact or myth? A systematic review and meta-analysis. *Eur J Orthop Surg Traumatol.* 2018;28(5):885-91.
- Burgess AR, Eastridge BJ, Young JW, et al. Pelvic ring disruptions: effective classification system and treatment protocols. *J Trauma.* 1990;30(7):848-56.
- Krueger MA, Green DA, Hoyt D, et al. Overlooked spine injuries associated with lumbar transverse process fractures. *Clin Orthop.* 1996;327:191-5.
- Brynin R, Gardiner L. Missed lumbar transverse process fractures in a high school football player. *J Manipulative Physiol Ther.* 2001;24(1):123-6.

16. Patten RM, Gunberg SR, Brandenburger DK. Frequency and importance of transverse process fractures in the lumbar vertebrae at helical abdominal CT in patients with trauma. *Radiology*. 2000; 215(3):831-4.
17. Lee YJ, Bong HJ, Kim JT, et al. Sacral insufficiency fracture, usually overlooked cause of lumbosacral pain. *J Korean Neurosurg Soc*. 2008;44(3):166-9.
18. Blake SP, Connors AM. Sacral insufficiency fracture. *Br J Radiol*. 2004;77:891-6.

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