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Validated Radiographic Scoring System for Lateral Compression Type 1(LC-1) Pelvis Fractures

James Beckmann, MD¹, Justin M Haller, MD², Michael Beebe, MD³, Ashley Ali, MD⁴, Angela Presson, PhD⁵, Ami Stuart, PhD⁶, H Claude Sagi, MD⁷, Erik Kubiak, MD⁸

¹St. Luke's Health System, Boise, ID

²Department of Orthopaedic Surgery, University of Utah School of Medicine, Salt Lake City, UT

³Department of Orthopedic Surgery, Campbell Clinic, Memphis, TN

⁴Department of Orthopaedic Surgery, University of South Florida, Tampa, FL

⁵Division of Epidemiology, Department of Internal Medicine, University of Utah, Salt Lake City, UT

⁶Department of Anesthesiology, University of Utah School of Medicine, Salt Lake City, UT

⁷Department of Orthopedic Surgery, University of Cincinnati, Cincinnati, OH

⁸University of Nevada, Reno School of Medicine, Las Vegas, NV

Abstract

Objectives: Develop a radiographic fracture scoring system for LC-1 pelvic fractures based on OTA survey data and preliminarily evaluate this system within a LC-1 pelvis fracture cohort.

Design: Survey study with validation patient cohort

Setting: 2 Level-1 academic trauma centers

Patients/Participants: 2013 OTA national meeting attendees (n = 111) reviewed imaging from 27 LC-1 fractures and indicated surgical recommendations ("yes/no"). A separate LC-1 fracture cohort (33 patients) was used to evaluate the scoring system.

Intervention: LC-1 scoring system (range: 5-14) based on radiographic morphology of sacral, superior ramus (SR), and inferior ramus (IR) fracture components

Main Outcome Measurement: Numeric scores were compared against 1) OTA attendees' operative recommendations and 2) LC-1 cohort treatment and outcomes.

Results: Operative tendency of OTA survey respondents – defined as the percent of "yes" responses to recommend surgical stabilization – was highly correlated with radiographic findings: sacral displacement [OR=18.9 (95% confidence interval CI: 11.7-30.6)]; sacral column 2-3 vs. 1 [OR=5.7 (95% CI: 3.9-8.3)]; Denis classification [OR=10 (95% CI: 6.7-14.9)]; IR displacement OR=3.4 (95% CI: 2.3-4.8)]; SR fracture [OR=1.9 (95% CI: 1.3-2.8)]. Total scores < 7 were 81%

accurate in predicting nonoperative treatment. Total scores > 9 were 89% accurate in predicting an operative recommendation. In the LC-1 cohort, scoring accuracy was 100% (95% CI: 85%-100%).

Conclusions: Based on survey results and patient cohort data, scores < 7 predict nonoperative treatment recommendation, scores >9 indicate surgical recommendations, and scores 7-9 indicate indeterminate stability that should be further evaluated

Level of Evidence: V, expert opinion

Introduction

Lateral compression type 1 (LC-1) pelvic fractures are common, representing nearly half of all pelvic fractures.¹ Historically, it was thought that LC-1 fractures were stable and nonoperative treatment was categorically recommended.² However, surgeons increasingly recognize that LC-1 injuries are more heterogeneous with varying degrees of stability. Many LC-1 fractures are associated with clinically significant instability and may require operative stabilization.^{3,4} Unfortunately, radiographic predictors of fracture stability are poorly defined and treatment remains controversial.⁵

LC-1 fracture treatment is typically based on fracture stability. Stable fractures can be treated conservatively because they are not expected to displace under normal physiologic forces. Conversely, there is general consensus that widely displaced fractures are likely unstable and require operative intervention.^{1, 6-9} The choice of operative versus nonoperative management is less clear in patients with less severe initial fracture displacement. In this situation, physicians often rely on a combination of imaging, clinical examination including relative pain with attempted mobilization, and examination under anesthesia (EUA).

Late displacement of nonoperatively treated LC-1 fractures can result in malunion or non-union, which could compromise patient outcomes. In several studies, persistent fracture displacement correlated with increased pain and decreased function,⁹⁻¹¹ and was associated with leg length discrepancy, gait anomalies, genitourinary problems, sexual dysfunction, and chronic pain.¹¹ Late displacement of fractures treated nonoperatively occurs because of unrecognized instability; early identification of these unstable injuries might permit earlier surgical intervention to prevent fracture displacement.¹²

Three column sacral fractures, sacral fracture displacement, Denis classification, superior rami (SR) fracture location, and inferior rami (IR) fracture displacement have all been proposed as potential radiographic determinants of fracture stability.^{3,13} However, a unified scoring system that uses sacral, SR, and IR fracture morphology and displacement to predict stability has not been described. The purpose of the study was to 1) determine whether certain radiographic characteristics of LC-1 fractures reliably correlate with surgeons' tendency to treat particular fractures operatively or nonoperatively; and 2) validate our scoring system with a series of LC-1 pelvis fractures. We hypothesized that 3-column sacral injuries and displaced sacral fractures would be the most predictive of operative tendency.

Materials and Methods

Surgical tendency for LC-1 pelvis fractures

Following IRB approval, 613 pelvic fractures treated at a tertiary-care level-I trauma center between 2009 and 2012 were identified, and 192 of the 613 fractures (31%) were classified as LC-1 patterns. Eighty-four of 192 patients (44%) had complete radiographic data available (axial CT imaging and AP/inlet/outlet pelvic radiographs or equivalent reconstruction).

Twenty-seven LC-1 cases were selected from the original 84 cases. Three static surveys containing 9 randomly selected cases each weighted for treatment decision difficulty were distributed (A, B, C) at the 2013 OTA annual meeting. Methods for case inclusion have been previously described.⁵

Each case was presented as pelvic radiographs (AP/inlet/outlet) and a scrollable CT scan using Quicktime player (Apple). Respondents were queried as to whether they would recommend operative stabilization (“yes/no”) based on the provided images. Each surgeon surveyed evaluated 9 distinct cases. Neither case descriptions nor physical exam findings were included. The percent of responses recommending operative stabilization (“yes”) was defined as the “operative tendency” for each case.

The 27 cases were scored for severity using our proposed scoring system (Table 1) by four fellowship-trained, attending orthopaedic trauma physicians and four residents from multiple institutions. Both attending and resident scorers were employed to assess inter-observer reliability and determine whether practice experience led to variations in our proposed scoring system.

Our proposed scoring system was based on radiographic fracture characteristics of the sacrum, inferior ramus, and superior ramus (Table 1). Sacral fractures were scored according to three separate criteria: 1) column involvement -- ranging from one point for single-column injury to three points for a complete, three-column injury (Figure 1a); 2) Denis classification -- scores ranging from one to three corresponding to zone; and 3) Sacral displacement (typically measured on axial imaging of the posterior sacral cortex) -- one point for < 2mm sacral displacement versus two points for displacement ≥ 2mm. Inferior ramus fractures were scored from one to three based on displacement (1=minimally displaced, 2=displaced greater than 1 mm with maintained medullary contact, 3=completely displaced or only cortical contact) (Figure 1b). SR fractures were scored based on modified Nakatani criteria (1=root fracture, 2=mid-ramus fracture, 3=parasymphyseal fracture)¹³ (Figure 1c). Total scores ranged from 5-14. This simple *ad-hoc* weighting scheme for calculating a total score was preferred over a weighting scheme developed by a multiple logistic regression model due to our limited sample size (27 LC-1 cases). The component severity scores and the summed total score for each fracture pattern were compared to the operative recommendations of OTA attendees to determine if the radiographic variables were predictive of operative tendency.

Scoring System Validation

We obtained a validation data set of 33 LC-1 fracture cases from a separate institution that has previously been described in detail.⁴ Five outcomes were identified in this cohort: 1) Operative stabilization without EUA due to presumed instability (n=10), 2) Operative stabilization following positive EUA (n=8), 3) Successful nonoperative treatment following negative EUA (n=2), 4) Unsuccessful nonoperative treatment with late radiographic displacement and delayed fixation (n=1), and 5) Successful nonoperative treatment without displacement and radiographic union (n=12). For the purpose of data analysis, groups 1, 2, and 4 were defined as unstable patterns, while groups 3 and 5 were considered stable patterns. Based on previous studies, a negative stress was defined as any injury with less than 1 cm of symphyseal/fracture overlap.⁴

The cohort cases were deidentified and scored by four raters at the participating center including three residents and one traumatologist without treatment knowledge. Each rater was blinded to the OTA survey results from part 1 of this study except one (JB). The total score was calculated for each rater, and this data set was used to validate the predictive findings from our original data set.

Statistical Methods

For the original LC-1 data set (with 27 LC-1 cases), severity scores were summarized for the senior and resident raters as percentages, medians, and means. Agreement between the raters was evaluated using intraclass correlation coefficients (ICCs). An ICC= 0-0.2 was considered poor agreement, 0.21-0.40 was considered fair and 0.41-0.60 was considered moderate agreement 0.61-0.80 as substantial, and 0.81-1 as almost perfect agreement.¹⁴ Logistic mixed effects regression models predicting operative stabilization were constructed where each observation consisted of operate yes/no for each case and each surgeon surveyed. There were 27 unique LC-1 cases (9 cases/survey), three surveys with A (n=36), B (n=29), and C (n=46) evaluators of operative stability. The rounded averaged severity scores within attendings and residents were calculated for each of the 27 cases and were our main (fixed effect) predictors of interest. Each model also included survey (A,B,C) as a fixed effect and case ID and surgeon ID as random effects modeled as random intercepts (using the lme4 package in R). Odds ratios and their 95% confidence intervals (CI) and p-values were reported from each model. Due to the limited sample size (27 unique LC-1 cases), each of the component LC-1 severity scores and the total severity score were modeled separately rather than building a multiple logistic regression model.

To visualize the relationships between operative decisions and our LC-1 severity scores, we also compared each severity component score to “% Operate” which was calculated by averaging the operative decisions for each unique LC-1 case and multiplying by 100. We plotted % Operate versus severity score for each rater, and Spearman correlations and p-values were presented in the plot titles.

With a case sample size of 27, it was not optimal to build a predictive model using multiple logistic regression due to the potential for overfitting and biased, ie, inaccurate coefficients.^{15,16} Furthermore, we desired to find an optimal threshold for each measure to facilitate

translation of the prediction scores into clinical practice. While identifying an optimal threshold also induces potential for overfitting, we decided that recursive partitioning and regression trees (RPART) would be a helpful compromise. To mitigate potential overfitting from RPART, we only allowed a single predictor to be included in our models. Furthermore, in addition to the individual measures we only considered the sum of the measures, rather than pursuing all possible sums of pair-wise or multi-group combinations of predictors. In this way, RPART was used to determine the top severity score(s) and threshold(s) for predicting cases where few would operate (% Operate < 10%), and cases where nearly everyone would operate (% Operate > 90%). Accuracy, sensitivity and specificity were provided for each optimal threshold for each rater. Positive and negative predictive values were not included because they are dependent on the prevalence of operative cases, and our sample was not reflective of a typical patient population (it was enriched for more potentially operative cases as this condition is rare). All statistical analyses were performed in R (v2.15.3) using a significance level of $p < 0.05$.¹⁷

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Results

Surgical tendency for LC-1 pelvis fractures

Complete responses were obtained from 111 OTA members as to whether they would recommend operative stabilization for each of 9 cases, for a total of 999 responses. Sixty-eight percent of respondents were fellowship trained in orthopaedic trauma, 57% had been in practice at least six years, and 74% reported treating greater than 20 LC-1 fractures annually. There were a total of 27 unique cases evaluated (9 per survey), and the average LC-1 scores for the attendings and residents for each case are provided in Supplemental Digital Content 1&2.

There was substantial agreement amongst all raters in the summed total score, which had an ICC = 0.77 (95% CI: 0.65-0.87, Supplemental Digital Content 3). Attendings and residents assigned similar total scores, with medians and interquartile ranges of 8 (6-9.5) and 8 (7-9.5), respectively. The Denis and SR subcomponents had the worst agreement (ICC = 0.58 and 0.55, respectively), while the IR subcomponent and the summed total score had the highest agreement on average (ICC = 0.70 and 0.77, respectively).

LC-1 severity scores for both sets of raters were highly correlated to operative decision (Table 2, Supplemental Digital Content 4&5). For attendings, sacral fracture displacement 2mm vs < 2mm, which had an OR = 18.9 (95% CI: 11.2-32.1) and Denis Zones 2-3 versus Zone 1, which had an OR = 10.0 (95% CI: 6.6-15.3) were the strongest predictors of operative tendency. Residents showed similar results, where results for sacral fracture displacement 2mm vs < 2mm with a OR = 18.9 (95% CI: 11.2-32.1), and Denis Zones 2-3

versus Zone 1, had an OR = 8.9 (95% CI: 5.9-13.5). The SR morphology showed the weakest association with operative tendency in both groups, and did not achieve significance amongst residents. For both the attendings and residents, a unit increase in the total score corresponded to approximately twice the odds of recommending operative intervention (OR=2.1, 95% CI: 1.9-2.4 in attendings and OR=2.2, 95% CI: 1.9-2.5 in residents).

Our survey results showed that there were five of 27 cases in which nearly no surgeon recommended operative treatment (% Operate < 10%) and four of 27 cases where nearly all surgeons recommended operative treatment (% Operate > 90%). In Supplemental Digital Content 6, diagnostic accuracy indicates the number of accurate predictions over the total number of predictions made (27), sensitivity indicates the rate at which cases recommended for surgery are predicted to be recommended based on our score threshold, and specificity indicates the rate at which cases not recommended for surgery are predicted to not need surgery. For example, for predicting operative cases where >90% of surgeons would recommend surgery, we had the following 2×2 table for our prediction accuracy results, where rows indicate our prediction (sum>9 True, False) and columns indicate membership to the >90% group (True, False):

	Operate > 90% True	Operate > 90% False	Total of Rows:
Sum > 9 True	4	3	7
Sum > 9 False	0	20	20
Total of Columns:	4	23	27

Diagnostic accuracy is calculated as $(4+20)/27 = 89\%$, sensitivity is calculated as $4/4 = 100\%$, and specificity is calculated as $20/23 = 87\%$. We consistently identified the total score as the top predictor, with accuracies of 81% (95% CI: 62-94%) for the cases with % Operate < 10% and 89% (95% CI: 71-98%) for the cases with % Operate > 90% (Supplemental Digital Content 6). Total score <7 was the best predictor of cases where fewer than 10% of surgeons would recommend an operation; a total score >9 was the best predictor of cases where more than 90% of surgeons would recommend an operation (Supplemental Digital Content 6).

Scoring System Validation

To validate the total score prediction thresholds, we obtained a rounded average of total scores among the four raters in our validation data set. Treatment outcomes by average radiographic score are shown in Table 3 and Figure 2. Using the metrics determined from the original data set (score > 9 indicates operate and score < 7 indicates no operation), there were 23 cases (70%) that were found to be in this range (15 operative vs. 8 nonoperative). Ten cases were scored in the “unsure” range with a total score of 7-9 (4 operative, 40%). Thus, our validation sample consisted of the set of n=23 that could be confidently scored. Accuracy was 100% (95% CI: 85%-100%) for the 23 cases in predicting treatment using the scoring system. Note that the lower bound of 85% is considered to offer “very good” prediction accuracy.¹⁸ Accuracy was also 100% for each rater considered separately, and the ICC for the raters was 89% (95% CI: 81-94%).

Discussion

The purpose of this study was to determine whether radiographic fracture characteristics can predict the likelihood with which OTA members recommend operative intervention for LC-1 pelvic fracture patterns and validate this scoring system based on a series of LC-1 fractures. Our results consistently demonstrated a strong relationship between increased operative tendency and sacral displacement >2mm (OR = 29.0; 95% CI 17.1-49.4) or three-column sacral involvement (OR = 27.7 versus 1-column fractures; 95% CI 16.9-45.4). The total score was the best predictor of operative tendency ($r=0.84$, $p < 0.001$), with every point increase in total score corresponding to an approximately two-fold increase in the odds of operative tendency. Our results confirm interplay between the anterior and posterior injuries in predicting stability, as addition of SR and IR fracture characteristics increased the predictive value of the model.

We defined groups based on operative tendency as non-operative (<10% operate, 5 cases) and operative (>90% operate, 4 cases), and found these groups were accurately defined by total scores of <7 and >9, respectively. Furthermore, we validated these thresholds in an independent data set, and found 100% (95% CI: 85%-100%) accuracy among the 23 evaluable cases in the separate validation cohort. These cutoffs have potential value for the orthopaedic traumatologist and non-traumatologist alike. At centers that do not routinely perform operative pelvic stabilization, on-call surgeons could potentially use this scoring system to delineate which LC-1 injuries could be successfully treated conservatively (e.g. total score <7) versus higher risk patterns that warrant referral to a traumatologist for further evaluation. For the traumatologist, scores of 7 to 9 may identify fracture patterns where little treatment consensus exists; these fracture patterns might potentially warrant EUA or some other method to determine stability. Finally, the scoring system provides a descriptive framework for consistently reporting results across centers and identifying areas of controversy that require further study.

The reliability of this scoring system appears promising. There was substantial overall agreement of LC-1 summed total scores between the attending traumatologists and residents (ICC = 0.77, 95% CI: 0.65-0.87). The high inter-observer reliability between both experienced traumatologists and senior residents suggests potential generalizability of the model. This is reassuring because ease of use and reproducibility of scoring are critical if the scoring system is to be used by general orthopaedists to triage LC-1 injuries. Further studies will determine the true interobserver reliability amongst orthopaedists with varying specialty training.

The scoring system was an accurate predictor of treatment decision in this small validation cohort. The scoring system evaluation in the validation cohort is based on two main assumptions. First, it assumes that operative stabilization was necessary in those LC-1 fractures treated with operative stabilization without EUA due to obvious instability. Secondly, it assumes that EUA is the gold standard for determining pelvic fracture stability, and that those patients with positive EUA required operative stabilization. Despite several studies have demonstrating success with EUA, it is currently unknown how best to measure displacement and how much displacement is acceptable.^{4,19-23} Whether EUA is the gold

standard for diagnosing LC-1 stability and surgical requirement is controversial; however, for orthopedic surgeons who ascribe to using EUA to guide operative treatment, we used the original LC-1 fracture patient cohort to validate our scoring system.⁴ More rigorous patient outcome studies for LC-1 pelvis fractures are needed to further guide treatment recommendations.

There are several weaknesses of this study. In this radiographic analysis, clinical exam findings were not available to survey respondents and respondents were not able to choose to perform an EUA. By limiting the available information or treatment, the study results do not fully replicate all clinical options. Another limitation is that the 27 cases for this study were selected to represent a wide array of injury patterns, and thus our results do not generalize to LC-1 injuries as encountered in practice. However, in an independent validation data set of LC-1 injuries encountered in practice, our scoring method applied to 23/33 (70% of cases) and achieved 100% accuracy. Furthermore, the scoring system was found to be reliable for both attending and residents raters in both the original data set (ICC = 0.77), and the validation data set (ICC = 0.89). The current study does not include complete determination of fracture stability or clinical outcomes, and cannot be used to correlate a radiographic score with final patient outcome. Finally, the small number of cases available in the validation cohort (n = 33) could limit the generalizability of our findings and will require additional research to validate the usefulness of this scoring system.

Conclusion

In this study, a radiographic scoring system based on sacral, SR, and IR fracture morphology was evaluated for predicting operative stabilization against survey results from OTA members and was subsequently applied to a cohort of LC-1 cases at a separate institution. There was good predictability for both high and low scores. A score < 7 indicated a propensity for nonoperative treatment among survey respondents with successful radiographic union in the validation cohort; a score >9 indicated a consensus that a patient may benefit from operative stabilization. Scores of 7-9 lacked consensus regarding appropriate treatment, and should be further evaluated or followed closely. Prospective clinical validation with larger patient cohorts will be needed before recommending the general clinical use of this scoring system.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

References

1. Weaver MJ, Bruinsma W, Toney E, Dafford E, Vrahas MS. What are the patterns of injury and displacement seen in lateral compression pelvic fractures? Clin Orthop Relat Res 2012 8;470(8): 2104–10. [PubMed: 22585347]
2. Burgess AR, Eastridge BJ, Young JW, Ellison TS, Ellison PS Jr, Poka A, Bathon GH, Brumback RJ. Pelvic ring disruptions: effective classification system and treatment protocols. J Trauma 1990;30:848–56. [PubMed: 2381002]

3. Bruce B, Reilly M, Sims S. OTA highlight paper predicting future displacement of nonoperatively managed lateral compression sacral fractures: can it be done? *J Orthop Trauma* 2011 9;25(9):523–7. [PubMed: 21857419]
4. Sagi HC, Coniglione FM, Stanford JH. Examination under anesthetic for occult pelvic ring instability. *J Orthop Trauma* 2011 9;25(9):529–36. [PubMed: 21857421]
5. Beckmann JT, Presson AP, Curtis SH, Haller JM, Stuart AR, Higgins TF, Kubiak EN. Operative Agreement on Lateral Compression-1 Pelvis Fractures Among 111 Orthopaedic Trauma Association Members. *J Orthop Trauma*. 2014;28:681–685. [PubMed: 24786733]
6. Tile M *Fractures of the pelvis and acetabulum*, 3rd ed., Baltimore: Williams & Wilkins; 2003 P3–21, 32–45, 116–128, 153–161.
7. Tile M *Pelvic Fractures: operative versus non-operative treatment*. *Orthop Clin North Am*. 1980;11:423–464 [PubMed: 7413169]
8. Bellabarba C, Ricci WM, BBohlofner BR. Distraction external fixation in lateral compression pelvic fractures. *J Orthop Trauma* 2006; 20(Suppl. 1):S7–14 [PubMed: 16385210]
9. Lindahl J, Hirvensalo E, Bostman O, Santavirta S. Failure of reduction with an external fixator in the management of injuries to the pelvic ring. *J Bone Joint Surg Br* 1999;81(6):955–62 [PubMed: 10615965]
10. Khoury A, Kreder H, Skrinkas T, Hardisty M, Tile M, Whyne CM. Lateral compression fracture of the pelvis represents a heterogeneous group of complex 3D patterns of displacement. *Injury* 2008;39:893–902. [PubMed: 18279874]
11. McLaren AC, Rorabeck CH, Halpenny J. Long-term pain and disability in relation to residual deformity after displaced pelvic ring fractures. *Can J Surg* 1990;33(6):431–2. [PubMed: 2253116]
12. Vaida R, Kubiak EN, Bergin PF, Dombroski DG, Chritchlow RJ, Sethi A, Starr AJ. Complications of anterior subcutaneous internal fixation for unstable pelvis fractures: a multicenter study. *Clin Orthop Relat Res* 2012 8;470(8):2124–31. [PubMed: 22219004]
13. Starr AJ, Nakatani T, Reinert CM, Cederberg K. Superior pubic ramus fractures fixed with percutaneous screws: what predicts fixation failure? *J Orthop Trauma* 2008;22(2):81–7. [PubMed: 18349774]
14. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics* 1977;33(1):159–174. [PubMed: 843571]
15. Peduzzi P, Concato J, Kemper E, Holford TR, Feinstein AR (1996) A simulation study of the number of events per variable in logistic regression analysis. *Journal of Clinical Epidemiology* 49:1373–1379. [PubMed: 8970487]
16. Harrell FE Jr.; Lee KL; Califf RM; Pryor DB; Rosati RA Regression modelling strategies for improved prognostic prediction. *Stat Med* 1984; 3 (2): 143–52. [PubMed: 6463451]
17. R Core Team (2013). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria ISBN 3-900051-07-0, URL <http://www.R-project.org/>.
18. Simundic AM. Measures of Diagnostic Accuracy. *EJIFCC* 2009;19(4): 203–211. [PubMed: 27683318]
19. Whiting PS, Auston D, Avilucea FR, Ross D, Archeacon M, Sciadini M, et al. Negative stress examination under anesthesia reliably predicts pelvic ring union without displacement. *J Orthop Trauma* 2016;31(4): 189–193.
20. Tornetta PI, Dickson K, MATTA JM. Outcome of Rotationally Unstable Pelvic Ring Injuries Treated Operatively. *Clin Orthop Relat Res*. 1996;329:147.
21. Gaski GE, Manson TT, Castillo RC, Slobogean GP, O'Toole RV. Nonoperative Treatment of Intermediate Severity Lateral Compression Type 1 Pelvic Ring Injuries With Minimally Displaced Complete Sacral Fracture. *J Orthop Trauma*. 2014;28(12):674–680. doi:10.1097/BOT.000000000000130. [PubMed: 24740110]
22. Lefavre K, Slobogean GP, Ngai JT, Broekhuysen HM, O'Brien PJ. What outcomes are important for patients after pelvic trauma? Subjective responses and psychometric analysis of three published pelvic-specific outcome instruments. *J Orthop Trauma* 2014;28(1):23–27. [PubMed: 23571293]
23. Lefavre K, Blachut PA, Starr AJ, Slobogean GP, O'Brien PJ. Radiographic displacement in pelvic ring disruption: reliability of 3 previously described measurement techniques. *J Orthop Trauma* 2014;28(3):160–165. [PubMed: 23760181]

Figure 1.
Scoring schematic for LC-1 pelvis fractures

Figure 2.
LC-1 Fracture Treatment Outcome by Score

Table 1:

LC1 Fracture Scoring Criteria.

Parameter	Points
<u>Sacral Displacement</u>	
< 2 mm	1
2 mm	2
<u>Denis Classification</u>	
Zone 1	1
Zone 2	2
Zone 3	3
<u>Sacral Columns</u>	
1 column	1
2 columns	2
3 columns	3
<u>Inferior Ramus Displacement</u>	
Minimal	1
>50%	2
Complete	3
<u>Superior Ramus Location</u>	
Root	1
Mid-ramus	2
Parasymphyseal	3

Table 2.

Results for logistic mixed effects models for operate yes/no, where the averaged scores were separately modeled for attendings and residents.

Score *	Attendings		Residents	
	Odds Ratio (95% CI)	p-value	Odds Ratio (95% CI)	p-value
Denis - 2/3 vs 1	10 (6.6-15.3)	p<0.001	8.9 (5.9-13.5)	p<0.001
Sacral Columns - 2/3 vs 1	5.7 (5.7-5.8)	p<0.001	7.5 (4.7-11.7)	p<0.001
Displacement - 2 vs 1	18.9 (11.2-32.1)	p<0.001	18.9 (11.2-32.1)	p<0.001
Superior Ramus - 2/3 vs 1	1.9 (1.3-2.8)	p<0.001	1.3 (0.9-1.9)	p=0.180
Inferior Ramus - 2/3 vs 1	3.3 (2.3-4.9)	p<0.001	3.6 (2.3-5.8)	p<0.001
Sum	2.1 (1.9-2.4)	p<0.001	2.2 (1.9-2.5)	p<0.001

* For Denis, Sacral Columns, Inferior Ramus and Superior Ramus scores 2-3 were combined due to low counts.

Table 3.

LC-1 case scores by treatment

ORIF without stress evaluation	14	13	10	12	12	10	12	12	13	12
+ Stress --> ORIF	10	13	11	13	10	9	11	8		
- Stress --> Nonop	8	6								
Nonop --> Displaced --> ORIF	10									
Nonop --> No displacement	9	5	5	5	7	7	9	5	8	6