A Worldwide Analysis of the Reliability and Perceived Importance of an Injury to the Posterior Ligamentous Complex in AO Type A Fractures

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Abstract

Study Design Survey of spine surgeons.

Objective To determine the reliability with which international spine surgeons identify a posterior ligamentous complex (PLC) injury in a patient with a compression-type vertebral body fracture (type A).

Methods A survey was sent to all AOSpine members from the six AO regions of the world. The survey consisted of 10 cases of type A fractures (2 subtype A1, 2 subtype A2, 3 subtype A3, and 3 subtype A4 fractures) with appropriate imaging (plain radiographs, computed tomography, and/or magnetic resonance imaging), and the respondent was asked to identify fractures with a PLC disruption, as well as to indicate if the integrity of the PLC would affect their treatment recommendation.

Results Five hundred twenty-nine spine surgeons from all six AO regions of the world completed the survey. The overall interobserver reliability in determining the integrity of the PLC was slight (kappa = 0.11). No substantial regional or experiential difference was identified in determining PLC integrity or its absence; however, a regional difference was identified ($p < 0.001$) in how PLC integrity influenced the treatment of type A fractures.

Keywords
- posterior ligamentous complex
- PLC
- reliability
- AOSpine Thoracolumbar Spine Injury Classification System
- M1 modifier

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Conclusion The results of this survey indicate that there is only slight international reliability in determining the integrity of the PLC in type A fractures. Although the biomechanical importance of the PLC is not in doubt, the inability to reliably determine the integrity of the PLC may limit the utility of the M1 modifier in the AOSpine Thoracolumbar Spine Injury Classification System.

Introduction

The two main goals of spine trauma classifications are to allow for communication between surgeons, researchers, and trainees and to guide the treatment. Some thoracolumbar fracture classifications such as the Magerl classification are based mainly on the bony injury morphology, which can be reliably evaluated on plain radiographs as well as computed tomography (CT).[1,2] However, because of the complexity of the Magerl system as well as the failure to formally consider the neurologic presentation of the patient, the clinical applicability of this classification system has been questioned.[2–6]

Recognizing the limitations of the Magerl system, Vaccaro et al published the thoracolumbar injury classification system (TLICS) in 2005.[3] The TLICS assigns a numerical value to the fracture morphology, the integrity of the posterior ligamentous complex (PLC), and the neurologic status of the patient, and the treatment recommendation is based on the summation of these three values.[3] Excellent reliability and validity of the system has been reported, with up to 96.2% agreement in the final treatment recommendation[7–9]; however, Harrop et al reported only fair reproducibility in the interpretation of the integrity of the PLC (kappa = 0.34).[10]

Without consistent agreement on the criteria that define the integrity of the PLC, the TLICS cannot properly guide the treatment of thoracolumbar burst fractures. In the TLICS algorithm, a burst fracture in a neurologically intact patient with an intact PLC is awarded 2 points, and an initial trial of nonoperative management is recommended. In a similar patient, if the PLC is clearly disrupted, 5 points are awarded and surgical intervention is warranted. If the status of the PLC is unclear, the TLICS fails to recommend a definitive treatment as the overall score of 4 points (indeterminate) places the treatment recommendation in a gray area, leaving it up to surgeon discretion. This failure of the TLICS, especially in burst-type fractures, has led to significant regional variations in the application of the proposed treatment algorithm. Recent studies from North and South America have reported successful nonoperative treatment of thoracolumbar burst fractures with and without a brace,[11,12] and concurrent studies from Europe have reported the successful treatment of similar bony injuries with a combined anterior and posterior fusion.[13,14]

In 2013, Vaccaro et al published the AOSpine Thoracolumbar Spine Injury Classification System.[15] In the new AOSpine classification, fractures are divided into three major types (A, compression; B, tension band injury; C, translational injury), and the neurologic status of the patient is divided into five groups (N0, neurologically intact; N1, transient neurologic deficit; N2, radiculopathy; N3, incomplete spinal cord injury; N4, complete spinal cord injury; NX, unable to asses neurologic status). A definitive ligamentous injury is defined as type B, but if there is uncertainty about ligamentous injury, a patient-specific modifier (M1) is assigned.[15] Eventually a Spine Injury Score will be established and used as the basis for a global algorithm for the treatment of the thoracolumbar trauma. However, prior to establishing what value should be awarded to the M1 modifier, it is critical to establish the agreement between surgeons to identify a possible PLC injury in a thoracolumbar compression (type A) fracture.

The TLICS was the first classification to formally recognize the importance of the integrity of the PLC on thoracolumbar fracture stability, and so it is possible that surgeons have become more adept at identifying PLC injuries since Harrop et al reported only fair agreement 1 year after the TLICS was published (kappa = 0.34)[3,10]; however, if surgeons can still not reliably agree on the presence of PLC injuries, then any classification system that makes the PLC a defining variable in the recommended treatment is bound to have the same shortcomings as the TLICS. The aim of this study is to determine the reliability of spine surgeons in indentifying a PLC injury in a compression-type fracture (type A) from the six AOSpine regions of the world (North America, South America, Europe, Africa, Asia, and the Middle East) and to determine their opinion on the perceived importance of the integrity of the PLC on the treatment algorithm.

Methods

A survey was sent to AOSpine members from the six AO regions of the world. The survey consisted of 10 cases of type A fractures (2 subtype A1, 2 subtype A2, 3 subtype A3, and 3 subtype A4 fractures) with appropriate imaging (plain radiographs, CT, and/or magnetic resonance imaging [MRI]), and the respondent was asked to identify fractures with a PLC disruption, as well as to indicate if the integrity of the PLC would affect their treatment recommendation.

The kappa statistic, as proposed by Cohen, was calculated for measuring the agreement among the investigators to a disruption in the PLC, and this was estimated by region and experience. The Landis and Koch grading system was used to interpret the kappa (►**Table 1**).[16] A chi-square test was used to test the independence of categorical responses, and the statistical significance was accepted as $p < 0.05$. The analysis was performed using the statistical software STATA version 13 (Stata Corporation, College Station, Texas, United States).

Table 1 Landis and Koch grading system[16]

Kappa value	Strength of agreement
<0.20	Slight
0.21–0.41	Fair
0.41–0.60	Moderate
0.61–0.80	Substantial
>0.81	Excellent

Table 3 Interobserver reliability by region

Region	Kappa value
Europe	0.17
Asia Pacific	0.08
Latin America	0.10
Middle East	0.07
North America	0.22
Africa	0.15

Results

Five hundred twenty-nine surgeons from the six AO regions of the world completed the survey (►**Table 2**). According to the total number of 5,290 assessments, around 84.1% answered the question "Do you see any significant injury to the posterior ligamentous complex (PLC)?" and 83.8% answered the question "Did the status of the posterior ligamentous complex (PLC) matter in your decision making?" The overall agreement on identifying disruption of the PLC was slight (kappa = 0.11). The interobserver reliability was highest in North America (kappa = 0.22), which also was the only region to attain fair (kappa > 0.20) reliability. All other regions demonstrated only slight reliability, and the reliability was the lowest in the Middle East (kappa = 0.07; ►**Table 3**). The interobserver reliability demonstrated only a minor improvement in the surgeons with more than 10 years of experience compared with the surgeons with less than 10 years of experience (kappa = 0.13 versus kappa = 0.10, respectively).

Significant ($p < 0.001$) regional variability was identified in the perceived importance of the integrity of the PLC among all compression-type fractures (A1, A2, A3, and A4; ►**Table 4**). Surgeons from North America reported that PLC integrity affected their treatment algorithm in 79.5% of cases, whereas surgeons from Europe reported that it only affected their recommended treatment in 61.2% of cases (►**Table 4**). When only burst fractures (A3 and A4) were included in the analysis, regional variability regarding the importance of the integrity of the PLC on the treatment algorithm remained ($p < 0.001$; ►**Table 4**). No difference was identified in the perceived importance of the PLC according to surgeon experience for all type A fractures, but when only burst fractures were considered, surgeons with more than 10 years of experience were more likely to have the integrity of the PLC affect their treatment recommendation (►**Table 5**).

Table 2 Demographics of respondents

	Total number	Percent
Region		
Europe	152	28.7
Asia Pacific	180	34.0
Latin America	79	14.9
Middle East	57	10.8
North America	33	10.8
Africa	7	1.3
Missing	21	4.0
Experience		
1–10 y	241	45.6
>10 y	285	53.9
Missing	3	0.6

Discussion

The goal of this study was to determine if international spine surgeons are able to reliably identify a PLC injury in a compression-type fracture (type A) and to determine their perception of the importance of the PLC on the treatment of type A fractures. Globally, we demonstrated only a slight interobserver reliability between spine surgeons (kappa = 0.11), and we demonstrated significant ($p < 0.001$) regional differences in the perceived importance of the PLC in type A fractures.

We hypothesized that the ability of spine surgeons to agree on the integrity of the PLC had improved substantially over the last 8 years, as it is one of the three main determinants of the TLICS. Instead, we found a substantial decline in the interobserver reliability compared with those reported in 2006 (kappa = 0.11 versus 0.34).[10] This decline may be due to the fact that in the previous study, the 30 surgeons who

Table 4 The effect of the integrity of the PLC on the treatment recommendation by region

Region	Integrity of the PLC affected treatment for type A fractures (%)	Integrity of the PLC affected treatment for type A3/A4 fractures (%)
Europe	61.2	54.3
Asia Pacific	73.0	67.1
Latin America	63.7	54.9
Middle East	76.9	73.2
North America	79.5	72.2
Africa	61.9	44.4

Abbreviation: PLC, posterior ligamentous complex.
Note: $p < 0.001$ for all regions

Table 5 The effect of the integrity of the PLC on the treatment recommendation by experience

Experience	Integrity of the PLC affected treatment for type A fractures (%)	Integrity of the PLC affected the treatment for type A3/A4 fractures (%)
1–10 y	67.4	58.7
>10 y	69.3	64.1
p value	0.19	<0.01

Abbreviation: PLC, posterior ligamentous complex.

completed the survey were a select group of academic spine surgeons who also helped develop the TLICS. Comparatively, in the current study, there were more than 10 times the number of surgeons surveyed, and none of them were responsible for the development of the AOSpine Thoracolumbar Spine Injury Classification System. Furthermore, in the current study, the surgeons were from throughout the world, which undoubtedly included some surgeons who practice in locations where MRIs are not routinely ordered to evaluate thoracolumbar type A fractures. Finally, and most importantly, the current study focused only on compression (type A) fractures, whereas the previous study had cases from all different fracture morphologies. The overall reliability would likely have been improved if more severe cases with an obvious PLC disruption, such as rotation/translation and distraction morphology, were included, as was the case in previous studies; however, this study focused on presumed type A fractures without clear signs of posterior distraction, because this is the only type in which the integrity of the PLC may be in question.

This study is one of a series of studies being performed to establish the intellectual foundation for a globally accepted algorithm for the treatment of thoracolumbar trauma based on the AOSpine Thoracolumbar Spine Injury Classification System. The failure to demonstrate any meaningful regional or experiential differences in the interobserver reliability of indentifying a PLC injury is consistent with the other studies performed. Schroeder et al demonstrated no regional or experiential difference in the perceived severity of subtypes of the AOSpine Thoracolumbar Spine Injury Classification System and demonstrated no regional or experiential difference in the radiographic interpretation of burst fractures with a single end plate (A3) or both end plates involved (A4).[17] Furthermore, Kepler et al demonstrated the globally applicability of the AOSpine Thoracolumbar Spine Injury Classification System by demonstrating moderate (kappa = 0.56) interobserver reliability in a worldwide survey of 100 spine surgeons without prior knowledge of the classification system.[18] However, with significant regional and experiential differences identified for the effect of the integrity of the PLC on the treatment algorithm and only slight interobserver reliability in identifying a PLC injury, the current study questions if the M1 modifier should be a pivotal piece in the thoracolumbar treatment algorithm. Using the results of the current and the aforementioned studies, the essential factors for a global algorithm for the treatment of thoracolumbar trauma based around the AOSpine Thoracolumbar Spine Injury Classification System are being identified.

This study has significant limitations, particularly those known to be inherent to survey studies in general. Although the survey was carefully designed by members of the AOSpine Trauma Knowledge Forum and all pertinent images were provided, the respondents did not have the opportunity to review the entire CT and MRI sequence. Undoubtedly, some respondents would have changed their answer if all CTs and MRIs were available; however, the current methodology was chosen for the sake of inclusiveness, as it allowed for 529 surgeons from all over the world to participate.

Conclusion

The interobserver reliability of an international group of spine surgeons to indentify an injury to the PLC in presumed type A injuries without clear signs of posterior distraction is only slight (kappa = 0.11), and there is a significant ($p < 0.001$) regional variability in how their perception of the integrity of the PLC affects their choice of treatment. These two findings indicate that the treatment algorithm associated with the AOSpine Thoracolumbar Spine Injury Classification System should be based primarily on fracture morphology and the neurologic status of the patient rather than the M1 modifier.

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AOSpine is a clinical division of the AO Foundation—an independent, medically guided, not-for-profit organization. The AO has a strong financial independence thanks to the foundation's endowment. The annual operating activities are financed through three pillars: collaboration and support agreements with DePuy Synthes and other industrial partners, return on own financial assets, and other third-party income (e.g., participant fees, R&D projects, memberships).

The AOSpine Knowledge Forums are pathology-focused working groups acting on behalf of AOSpine in their domain of scientific expertise. Each forum consists of a steering committee of up to 10 international spine experts who meet biannually to discuss research, assess the best evidence for current practices, and formulate clinical trials to advance their field of spine expertise. Authors are compensated for their travel and accommodation costs. Study support is provided directly through AOSpine's Research department and AO's Clinical Investigation and Documentation unit. There are no other institutional subsidies, corporate affiliations, or funding sources supporting this work unless clearly documented and disclosed.

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