

# The AOSpine thoracolumbar spine injury classification system: A comparative study with the thoracolumbar injury classification system and severity score in children

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## Abstract

**Background:** There is no uniform classification in the pediatric population for thoracolumbar (TL) fractures, nor any operative guidelines. This study evaluates the AOSpine TL spine injury classification in the pediatric population and compares it to the thoracolumbar injury classification system (TLICS), which has previously been validated in pediatric spine trauma.

**Methods:** Twenty-eight patients with operative TL injuries were identified from 2006 to 2016. Inclusion criteria included available imaging, operative records, age <18, and posterior approach. Each case was classified by AOSpine TL spine injury classification and TLICS. Each classification was compared to documented intraoperative posterior ligamentous complex (PLC) integrity as well as each other.

**Results:** Utilizing the AOSpine TL spine injury classification, 7 patients had type A injuries, 15 patients had type B injuries, and 6 patients had type C injuries; 21 patients had injuries classified as involving the PLC. Using TLICS, 16 patients had burst fractures, 6 patients had distraction injuries, and 6 patients had translation injuries; 21 patients had injuries classified as involving the PLC. Spearman correlation analysis substantiated convergence of AOSpine TL spine injury classification scores to TLICS scores ( $r=0.75$ ; 95% confidence interval, CI=0.51 to 0.98;  $P<.001$ ). Concordance between PLC integrity by each classification and intraoperative evaluation was 96% (27/28) of cases ( $k=0.91$ ; 95% CI=0.73 to 1.08). Neurologic status was 100% concordant between the AOSpine TL spine injury classification and TLICS.

**Conclusion:** There is high statistical correlation between the AOSpine TL spine injury classification and TLICS, and to intraoperative evaluation of the PLC, suggesting that the AOSpine TL spine injury classification is applicable to the pediatric population.

**Level of evidence:** III.

**Keywords:** AOSpine Thoracolumbar Injury Classification, spine, TLICS, trauma

## 1. Introduction

Pediatric TL fractures vary in severity, type, and resultant patient morbidity. Treatments range from observation to surgery

depending on factors such as fracture stability, displacement, and neurologic status. Despite the discordance in presentation, there does not yet exist a dedicated classification system for pediatric TL fractures. Meanwhile, there have been significant endeavors in developing classification systems of TL injuries in adults. These systems evolved from simple morphologic classifications to more complex systems based on fracture morphology (injury mechanism), evaluation of posterior ligamentous integrity, and neurologic status of the patient.<sup>[1-3]</sup>

The AOSpine Foundation has spent considerable effort to devise the new AOSpine TLICS.<sup>[4]</sup> This classification considers fracture morphology (injury mechanism), evidence of posterior ligamentous integrity, neurologic status of the patient, as well as patient-specific modifiers to classify injuries. The greater the evidence of PLC injury, the more severe the fracture is thought to be with subsequent potential for instability, ultimately risking severe deformity and subsequent neurologic decline. Independent evaluations have validated interobserver and intraobserver reliability.<sup>[5,6]</sup> This system has roots in the Magerl and Denis classification systems as well as the TLICS.<sup>[7,8]</sup> TLICS evolved as a way to guide surgeons for treatment of these injuries based on a point system based on fracture morphology (proposed mechanism), posterior ligamentous injury, and neurologic status of the patient. The goal of this system, as well as the AOSpine TLICS, has been to provide a unified framework of classification and

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treatment recommendations. TLICS has additionally been validated as a reliable system in the assessment of pediatric fractures.<sup>[9]</sup> The AOSpine TL spine injury classification is intended as a replacement to the TLICS. However, there are currently no studies assessing the newest AOSpine TL injury classification in children. The benefits of a standard classification system are many, including, but not limited to, consistent physician communication regarding fracture type, accurate data classification for research studies, and, ultimately, consensus treatment recommendations.

The purpose of this study was to determine if the new AOSpine TL spine injury classification is transferable to the pediatric population by comparing it to the TLICS classification, which has been previously validated in the pediatric population. By adapting the AOSpine TL spine injury classification, efforts can be directed toward modification and improvement rather than creating a pediatric classification de novo.

## 2. Methods

A retrospective institutional review was performed. An internal trauma database at a single institution was queried for patients under the age of 18 years who had been treated operatively for a TL fracture between 2006 and 2016. Inclusion criteria included patients with preinjury computed tomography (CT) scans and magnetic resonance imaging (MRI), who were less than 18 years of age, and who were treated operatively for a TL fracture via a posterior surgical approach with available operative reports detailing assessment of the PLC. TLICS and AOSpine TL spine injury classifications were applied to the CT and MRI studies of each patient who met the study criteria. A single, pediatric spine trauma senior attending rated each case. Cases were deidentified and randomized, and then classified according to the TLICS. They were again randomized and classified according to the AOSpine TL spine injury classification.

For the AOSpine TL spine injury classification, recording of each part of the classification system was performed (morphology, neurologic status, and patient modifiers). Injury morphology was classified as an A injury (compression), B injury (distraction), or C injury (translation). The main injury was recorded and classified. Type A fractures were graded in increasing severity as follows: A0 (simple), A1 (compression), A2 (pincer), A3 (burst involving one endplate), and A4 (burst involving both endplates) (Fig. 1). Type B fractures included classic bony chance (B1), failure of the posterior tension band such as horizontal fracture lines through the posterior elements or evidence of posterior ligamentous disruption (B2) (Fig. 2), and hyperextension injuries (B3). Type C fractures/injuries demonstrate dissociation between cranial and caudal segments (Fig. 3). If more than one injury was evident, the most severe injury was recorded.

The neurologic status of each patient was recorded from N1 to N4 as follows: N0 intact, N1 transient injury resolved, N2 radiculopathy, N3 incomplete/cauda equina, and N4 complete. NX is defined as neurologic examination unobtainable. Modifiers were also recorded for each patient. These modifiers include M1 and M2, which relate to patient-specific modifiers that may affect treatment (such as poor bone quality) or if there was potential for posterior ligamentous injury but was indeterminable. If the fracture could not be classified, it was deemed unclassifiable.

For the AOSpine TL spine injury classification, associated point scores were determined.<sup>[10]</sup> The points were assigned as follows: A0 (0-points), A1 (1-point), A2 (2-points), A3 (3-points), A4 (5-points), B1 (5-points), B2 (6-points), B3 (7-points),



**Figure 1.** CT sagittal image demonstrating A4 complete burst of the L5 vertebra.

C (8-points), N0 (0-points), N1 (1-point), N2 (2-points), N3 (4-points), N4 (4-points), NX (3-points), M1 (1-point), and M2 (0-points). Under this classification, nonoperative treatment is recommended for those with a score of 3-points or less, and operative treatment is recommended for those with scores of 5-points or more. Treatment of those with 4-points or 5-points can be treated either conservatively or operatively.

The patient cohort was also graded using TLICS, as well as the associated point total classification scoring system. The three components of the TLICS used for grading were fracture morphology (compression injury 1-point, burst injury 2-points, translation injury 3-points, distraction injury 4-points), integrity of the PLC (intact 0-points, suspected 2-points, injured 3-points), and neurologic status of the patient (intact 0-points, nerve root 1-point, complete neurologic injury 2-points, incomplete neurologic injury/cauda equina 3-points).

For patients who underwent a posterior procedure, relationships between classification systems and with operative findings (documented integrity or injury of the PLC as noted from operative reports) were analyzed. Convergence of preoperative



**Figure 2.** MRI sagittal cut demonstrating B2-A4 injury with PLC disruption.

AOSpine classification scores to TLICS scores was analyzed using Spearman rank correlation analysis. Operative reports were reviewed to determine the true status of the PLC at the time of the operation. Agreement between expected PLC injuries as assessed preoperatively using the TLICS or AOSpine classification systems and intraoperative findings of the true extent of PLC injury was analyzed using Cohen kappa ( $k$ ) coefficient along with 95% CIs. Sensitivity and specificity of each classification system to the intraoperative evaluation for detecting PLC injury were calculated.

### 3. Results

Twenty-eight patients met the inclusion criteria. The mean age at injury was 13.8 years (range 3.6–17.8 years). The mechanism of injury was motor vehicle accident ( $n=17$ , 61%), fall ( $n=8$ , 28%), and sports related ( $n=3$ , 11%); 27 patients underwent a posterior approach procedure and 1 patient had a combined procedure (Table 1).

Utilizing the AOSpine TL spine injury classification, 6 patients had type A injuries, 15 patients had type B injuries, and 7 patients had type C injuries; 21 patients had injuries classified as involving the PLC. The neurologic status of the patients was 15 (N0), 0 (N1), 2 (N2), 4 (N3), and 7 (N4). The mean AOSpine score was 8 (range 5–12); 24 patients had AOSpine scores greater than 24.

Utilizing TLICS, there were 16 burst fractures, 6 distraction injuries, and 6 translation injuries; 21 patients had injuries classified as involving the PLC. The neurologic injuries included 15 intact, 2 nerve root injuries, 7 complete spinal cord injuries, and 4 incomplete/cauda equina injuries. The mean TLICS score was 6 (range 2–9) and 22 patients had TLICS greater than or equal to 5.

Spearman correlation analysis substantiated convergence of AOSpine classification scores to TLICS scores ( $r=0.75$ ; 95%



**Figure 3.** CT sagittal demonstrating C-type injury with L2-L3 translation.

CI=0.51 to 0.98;  $P<.001$ ). Comparison of the classification systems confirmed the neurologic injuries and grading of the injury to the PLC in all cases. Of the full cohort, the grading of injured/noninjured PLC was confirmed at the operation in 27/28 (96%) cases. Agreement between intraoperative findings and preoperative AOSpine and TLICS-expected PLC status was near perfect for both ( $k=0.91$ ; 95% CI=0.73 to 1.08). In one patient, the fracture was classified on imaging to involve the PLC, but review of the operative reports showed that the PLC was intact at the time of the operation. Sensitivity and specificity of each classification system to the intraoperative evaluation for detecting PLC injury were 100% and 88%, respectively.

Twenty-two (79%) cases met the TLICS score cutoff for operative treatment ( $\geq 5$ -points). In the 6 cases where the TLICS was less than a score of 5, the PLC was noted to be intact at the time of operation. Surgical intervention was elected by the attending surgeon due to the degree of kyphosis and/or level of the fracture (3 fractures were at the TL junction and 1 at L5). One patient had a nerve root deficit that required decompression and 1 patient was suspected to have a PLC injury (2-points on the TLICS), which was not identified surgically.

**Table 1**  
**Patient, injury, and surgical characteristics (N=28).**

| Characteristic            | Frequency | %   |
|---------------------------|-----------|-----|
| Age, years; mean $\pm$ SD | 13.8      | 3.6 |
| Mechanism of injury       |           |     |
| Motor vehicle accident    | 17        | 61% |
| Fall                      | 8         | 28% |
| Sports related            | 3         | 11% |
| Procedure type            |           |     |
| Posterior                 | 27        | 96% |
| Combination               | 1         | 4%  |
| Injury classification     |           |     |
| AOSpine                   |           |     |
| A                         | 6         | 25% |
| B                         | 15        | 50% |
| C                         | 7         | 15% |
| Neurologic status         |           |     |
| N0                        | 15        | 54% |
| N1                        | 0         | 0%  |
| N2                        | 2         | 7%  |
| N3                        | 4         | 14% |
| N4                        | 7         | 25% |
| TLICS score, median (IQR) |           |     |
| $\geq 5$                  | 22        | 79% |
| PLC involvement           | 21        | 75% |
| AOSpine score             |           |     |
| $> 5$                     | 24        | 86% |

IQR, interquartile range; SD, standard deviation.

#### 4. Discussion

TL spine trauma classifications have evolved from the studies initially performed by Denis and Magerl. Over the last 2 decades, numerous studies and classification systems have been created through a series of modifications. TLICS unifies many of these systems and their ideology, considering fracture morphology, integrity of posterior ligamentous structures, and the neurologic status of the patient. A significant benefit of TLICS is a point-based grading system, enabling treatment recommendations.

The fundamental goal of the operative treatment is to achieve spinal stability and protect neurologic function. TLICS scores with higher point totals indicate fractures that have associated instability or neurologic injury. Fracture classification has further developed overtime and evolved with the newer AOSpine TL spine injury classification. This classification is also based on fracture morphology, posterior ligamentous integrity, and the neurologic status of the patient. This classification, however, is expanded and ranges from simple avulsion fractures of the spine (A0) in a patient with no neurologic injury to severe translational injuries (type C) with complete neurologic loss. A significant aspect of the classification system is determining injury to the PLC, accomplished by looking at CT scans alone. This can be supplemented by reviewing MRI also. The greater the evidence of PLC injury, the more severe the fracture is thought to be with subsequent potential for instability, ultimately risking severe deformity and subsequent neurologic decline.

Pediatric TL fractures are commonly grouped into compression fractures, burst fractures, chance injuries, and injuries with translation. There is currently no uniform classification system in the pediatric population, and there is 1 study to date validating TLICS in children.<sup>[9]</sup> Additionally, there are no operative

guidelines for surgeons taking care of children with spinal trauma. Spinal stability and neurologic preservation remain the hallmark of treatment and many surgeons use the principles of the TLICS to guide treatment.

The goal of our study was to take the newly created AOSpine TL spine injury classification and apply it to our trauma population to determine applicability to the pediatric population. The AOSpine foundation has put significant work into building this classification in the adult population to create a comprehensive system that is reliable and can enable surgeon communication as well as guide treatment. Rather than repeating the work of the AOSpine Foundation and creating an independent system, we compared the AOSpine TL spine injury classification to the TLICS with intraoperative observations of the PLC as a gold standard. There are understandable limitations to this approach, including the retrospective nature of our study and anatomic differences with children and varying states of skeletal maturity. However, our results show high concordance (agreeability) and reliability between the AOSpine TL spine injury classification, TLICS, and intraoperative findings. Additionally, the case cohort in this study was limited, and all were operative.

Analyzing the PLC associated with burst fractures was accomplished in this study based on the guidelines set forth in the classification system, utilizing both CT and MRI. There is inherent bias in this study as it involves only operative cases, suggesting that selected cases would have a minimum B component. However, at our institution, the operative treatment of the burst fractures follows the guidelines of TLICS, which inherently biases an operation when the posterior ligamentous structures are injured, and when there is a neurologic deficit.

This study functions as a proof of concept, preliminarily assessing the potential of the AOSpine TL spine injury classification in the pediatric population. More comprehensive validity studies are required, but thus far the findings in this study are promising. A follow-up study currently underway randomizes operative and nonoperative pediatric spine trauma cases, utilizing multiple reviewers to assess the intraobserver and interobserver reliability of the AOSpine TL spine injury classification.

#### 5. Conclusion

Fracture morphology has classically been the mainstay of classification systems and is fundamentally based on injury mechanism. The AOSpine TL spine injury classification is based on the principle of type A injuries describing compression, type B injuries describing distraction, and type C injuries describing more significant translation. The AOSpine TL spine injury classification applies well with the commonly seen fractures in the pediatric population. These include compression fractures, burst fractures, chance fractures, and more severe translation injuries. Our results show agreeability and reliability between the AOSpine TL spine injury classification, TLICS, and intraoperative findings.

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