The Subaxial Cervical AO Spine Injury Score

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Abstract

Study Design: Global cross-sectional survey.

Objective: To develop an injury score for the AO Spine Subaxial Cervical Spine Injury Classification System.

Methods: Respondents numerically graded each variable within the classification system for severity. Based on the results, and with input from the AO Spine Trauma Knowledge Forum, the Subaxial Cervical AO Spine Injury Score was developed.

Results: An A0 injury was assigned an injury score of 0, A1 a score of 1, and A2 a score of 2. Given the significant increase in severity, A3 was given a score of 4. Based on equal severity assessment, A4 and B1 were both assigned a score of 5. B2 and B3 injuries were assigned a score of 6. Unstable C-type injuries were given a score of 7. Stable F1 injuries were assigned a score of 2, with a 2-point increase for F2 injuries. Likewise, F3 injuries received a score of 5, whereas more unstable F4 injuries a score of 7. Neurologic status severity rating scores increased stepwise, with scores of 0 for N0, 1 for N1, and 2 for N2. Consistent with the Thoracolumbar AO Spine Injury Score, N3 (incomplete) and N4 (complete) injuries were given a score of 4. Finally, case-specific modifiers M1 (PLC injury) received a score of 1, while M2 (critical disc herniation) and M3 (spine stiffening disease) received a score of 4.

Conclusions: The Subaxial Cervical AO Spine Injury Score is an easy-to-use metric that can help develop a surgical algorithm to supplement the AO Spine Subaxial Cervical Spine Injury Classification System.

Keywords

AO Spine Subaxial Cervical Spine Injury Classification System, injury score, cervical spine trauma

Introduction

Traumatic cervical spine injuries are a relatively common sequelae of blunt trauma.[1-6] While the entire cervical spine is prone to injury, the subaxial cervical spine, which extends from C3 to C7, accounts for approximately half of these injuries.[3,4,6] Despite the numerous classification systems that exist for these injuries, few reliable treatment recommendations exist, and none are universally accepted. Consequently, treatment decisions are based on individual experience rather than evidence or consensus-based algorithms.[4,7-10]

While the "mechanism of injury" based classification system originally proposed by Allen et al. and subsequently modified by Harris et al. was comprehensive, it lacked reliability which limited its clinical utility.[3-9] Similarly, the Subaxial Injury Classification

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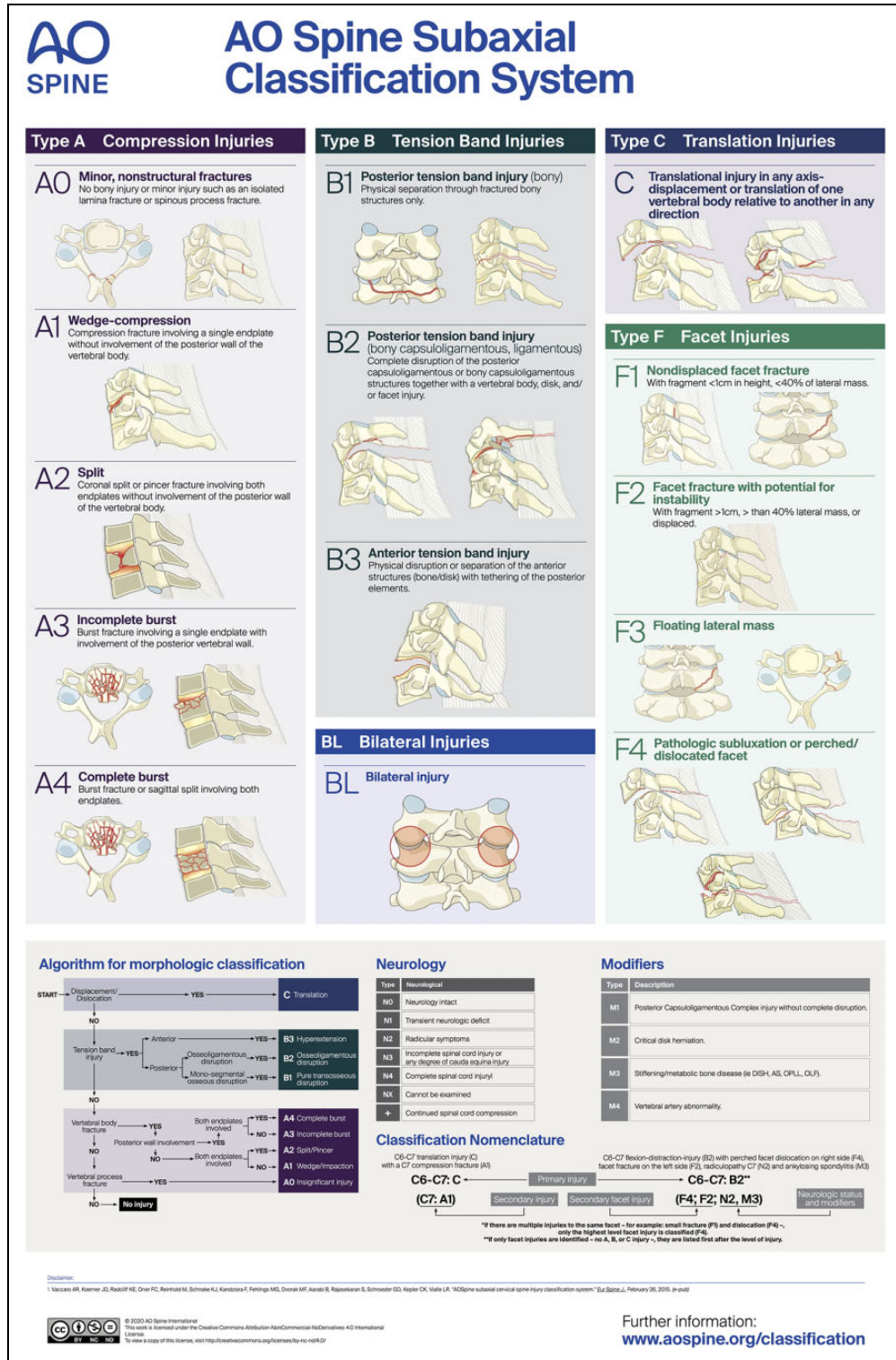
Figure 1. AO Spine subaxial cervical spine injury classification. Reprinted with permission from AO Spine International. © AO Foundation, Switzerland.

System (SLIC) developed by the Spine Trauma Group lacked distinct and clinically relevant morphological injury patterns, which again impaired the classification system's ability to standardize treatment decisions.[10] In an attempt to address this issue, AO Spine produced the Subaxial Cervical Spine Injury Classification System (AO Spine SCICS) (Figure 1), much in the same way as the AO Spine Thoracolumbar Spine Injury Classification System (AO Spine TLICS) was generated.[7,8,11,12]

The purpose of an effective classification system is to provide distinct and clinically relevant morphological descriptions of injury patterns in a manner that helps guide treatment. The AO Spine SCICS, which follows the same hierarchical approach as prior AO classification schemes, classifies injuries based on 4 parameters: (1) injury morphology, (2) facet involvement, (3) neurological status, and (4) case-specific modifiers.[7] Injury morphology is divided into 3 injury subgroups: A (compression injuries), B (tension band injuries), and C (translational injuries in any axis). Within these subgroups, Type A and Type B injuries are further divided into 5 (A0-A4) and 3 (B1-B3) subtypes, respectively. Facet involvement is divided in 4 subtypes: F1 (nondisplaced fracture), F2 (unstable fracture), F3 (floating lateral mass), and F4 (dislocation). The system also integrates the assessment of neurological status, which is divided into 6 subtypes (N0-N4, NX), and includes 4 case-specific modifiers: posterior capsuloligamentous complex injury without complete disruption (M1), critical disc herniations (M2), the presence of a metabolic bone/stiffening disease (M3), and signs of vertebral artery involvement (M4). The AO Spine SCICS, in multiple blinded evaluations from numerous institutions, has demonstrated moderate to substantial inter- and intra-observer reliability for classifying injuries with interobserver reliability kappa coefficients ranging from 0.57 to 0.64, and intraobserver reproducibility from 0.54 to 0.95.[1,7,13-15] Therefore, establishing a scoring system based on the relative injury severity associated with the above-mentioned subgroups is the next step in establishing treatment guidelines.

Generating a scoring system based on a consensus of relative injury severity follows the precedent set by numerous other classification systems.[16,17] Establishing universally accepted treatment guidelines based on this system is nonetheless a challenge, as many of the injury patterns described in the classification are rare and consequently prone to treatment based on personal or regional preference secondary to a lack of evidence-based guidelines.[18] While this makes generating an accepted treatment algorithm difficult, it also highlights its necessity, as having a classification system with management recommendations based on global consensus can help patients with these rare injuries.[19]

The purpose of this study is to establish a Subaxial Cervical AO Spine Injury Score (Subaxial AOSIS) to accompany the AO Spine SCICS. This process will be accomplished by rendering survey data from spine surgeons around the globe regarding the relative injury severity associated with each of the AO Spine SCICS subgroups into a score that communicates the need for surgical stabilization.[19] The thresholds used to delineate which injury subgroups should be addressed with surgical stabilization will be established at a later date, and will likely take numerous variables into account secondary to lack of existing evidence-based literature.

Methods

The AO Spine SCICS was developed by a consensus of spine surgeons via a process previously described.[7] The surgeons involved in this process address cervical spine injuries via a spectrum of different algorithms and thus represent several of the most common schools of thought surrounding the treatment of these injuries. Nonetheless, this group represents a small proportion of the surgical spine community and thus a resulting scoring system derived from it requires a larger and more diverse input if it is to be an instrument for surgical decision making.

A survey was sent to the members of the AO Spine Cervical Classification Validation Group composed of spine surgeons from 6 different world regions (North America, South America, Europe, Africa, Asia, and the Middle East). For each of the subgroups of the AO Spine SCICS, respondents were queried for a perceived numerical severity grade. A grade of zero was assigned to an injury of minimal severity, whereas a grade of 100 was ascribed to injuries with the highest severity, all of which were relative to the need and urgency for surgical stabilization. Questionnaires with at least one valid answer were included in the final analysis. The complete results of the survey study have been previously described.[19]

Analysis of the results of the survey were used to rank each subgroup of the classification system into a hierarchical arrangement based on point values assigned to represent relative injury severity.[18] Scores were assigned to each subgroup based on their relative injury severity rating. It is important to note that integer numbers are used, as non-integer point values would be cumbersome and impractical. Additionally, the M4 modifier (describing a vascular injury/abnormality) does not factor into a spine surgeon's surgical decision-making process, and a point value is therefore not applicable.

Results

Of the 272 surgeons surveyed, 195 (72%) responded. Six surveys did not meet inclusion criteria and were therefore excluded, leaving 189 (69%) surveys considered for final analysis. Respondent characteristics are summarized in Table 1.

As previously reported,[19] our results demonstrate a stepwise hierarchical progression, with few exceptions, within each of the 4 classification parameters (injury morphology, facet involvement, neurological status, and case modifiers) for subgroups and their associated subtypes (Table 2). For example, the injury severity rating of an A3 injury is greater than an A1 injury and a C injury is greater than a B1 injury. As a result of these hierarchical injury severity ratings, each subgroup or associated subtype in the AO Spine SCICS was unintentionally almost always scored higher than its alphanumerical predecessor (Tables 3-5). Exceptions include the transition from an A4 injury (complete burst or sagittal split fracture involving the posterior wall) to a B1 injury (monosegmental osseous failure of the posterior tension band extending into the vertebral body) (A4 60 [50.0, 80.0] vs. B1 60 [45.0, 70.0]), and the transition between B2 injuries (disruption of the posterior tension band with or without osseous involvement) and B3 injuries (anterior tension band injury with disruption or separation of the anterior

Table 1. Responder Demographics.

	Total Responders (n = 189)
Subspecialty*	
Orthopaedic Spine	131 (69.3)
Neurosurgery	58 (30.7)
Region*	
North America	18 (9.5)
Latin/South America	40 (21.2)
Europe	70 (37.0)
Africa	12 (6.3)
Asia	34 (18.0)
Middle East	15 (7.9)
No. of Years in Practice*	
< 5 years	50 (26.5)
5-10 years	61 (32.3)
11-20 years	50 (26.5)
> 20 years	28 (14.8)
Work Setting*	
Academic	78 (41.3)
Hospital Employed	88 (46.6)
Private Practice	23 (12.2)
No. of Spine Trauma Patients Treated per year**	50 (20; 100)
Time to Obtain an MRI at Home Institution*	
< 2 hours	52 (27.5)
2-12 hours	62 (32.8)
12-24 hours	28 (14.8)
> 24 hours	42 (22.2)
Cannot Obtain	5 (2.6)

* Proportions presented as: Number of Responders (%).
** Number presented as: Median (Interquartile Range).

Table 2. Median Injury Severity Score for Each Variable in the AO Spine Subaxial Cervical Spine Injury Classification System.

Type	No. of respondents	Median (IQR)
A0	178	5.0 (0.0; 10.0)
A1	179	20.0 (10.0; 25.0)
A2	179	30.0 (20.0; 50.0)
A3	179	50.0 (30.0; 60.0)
A4	179	60.0 (50.0; 80.0)
B1	179	60.0 (45.0; 70.0)
B2	179	80.0 (70.0; 85.0)
B3	179	80.0 (70.0; 90.0)
C	178	100.0 (100.0; 100.0)
F1	179	20.0 (10.0; 30.0)
F2	179	40.0 (30.0; 50.0)
F3	179	50.0 (40.0; 70.0)
F4	179	100.0 (85.0; 100.0)
N0	178	0.0 (0.0; 0.0)
N1	178	20.0 (10.0; 30.0)
N2	178	40.0 (30.0; 50.0)
N3	178	80.0 (70.0; 100.0)
N4	178	100.0 (85.0; 100.0)
NX	178	80.0 (50.0; 100.0)
M1	178	40.0 (30.0; 60.0)
M2	178	70.0 (50.0; 80.0)
M3	178	70.0 (60.0; 80.0)
M4	178	60.0 (50.0; 80.0)

IQR: Interquartile range.

Table 3. Point Allocation Based on Morphology Type.

Subgroup	Points
Type A-	
A0	0
A1	1
A2	2
A3	4
A4	5
Type B-	
B1	5
B2	6
B3	6
Type C-	
C	7

Table 4. Point Allocation Based on Facet Involvement.

Subgroup	Points
Facet involvement	
F1	2
F2	4
F3	5
F4	7

structures) (B2 80 [70.0, 85.0] vs B3 80 [70.0, 90.0]. All results are summarized in Table 2.

The scoring system for injury morphology can be seen in Table 3. An A0 injury was given a score of zero. Based on the hierarchical severity ratings, an A1 injury received a score of 1, as it only involves a single endplate and the posterior wall is unaffected. The A2 subtype received a score of 2, given the general concern for associated instability in coronal split fractures, and the possibility that this morphology may truly represent a Type B injury.[7,18,20-23] Analogously, an A3 injury was given a score of 4, due to associated posterior wall involvement. The scores for A4 and B1 injuries are both 5, while the scores for B2 and B3 injuries are both 6 secondary to their comparable injury severity ratings, respectively. A type C injury received a score of 7, as it is by definition a translational injury leading to significant displacement.[7]

The scoring system for facet involvement can be seen in Table 4. There is a 2-point score progression from F1 to F2 secondary to the 20-point injury severity rating increase that accompanies this transition from a stable to unstable injury pattern (F1 20 [10.0, 30.0] vs. F2 40 [30.0, 50.0]).[7,18] The remainder of the facet involvement subgroups increase in a proportional fashion to perceived severity rating, ending in a score of 7 for an associated dislocation (F4).

The scoring system for the neurologic status associated with a patient's injury can be seen in Table 5. There is an uneven stepwise progression in perceived injury severity, similar to what was seen with the transition from F1 to F2 injuries, with regard to the transition from a condition with signs or symptoms of radiculopathy (N2) to either an incomplete or a complete injury of the spinal cord (N3 and N4). Therefore, the score

Table 5. Point Allocation Based on Neurologic Status and Modifiers.

Subgroup	Points
Neurologic Status	
N0	0
N1	1
N2	2
N3	4
N4	4
NX	3
Case-Specific Modifiers	
M1	2
M2	4
M3	4
M4	N/A

assigned to a neurologically intact patient (N0) and those patients with radicular symptoms, either transient (N1) or persistent (N2), are 0, 1, and 2, respectively. However, due to a 40 point increase on the perceived injury severity rating scale from N2 to N3 (N2 40 [30.0, 50.0] vs N3 80 [70.0, 100.0]), a patient with an incomplete (N3) and one with a complete (N4) spinal cord injury both receive a score of 4. Patients who present with an unobtainable neurological exam (NX) are assigned a score of 3 out of an abundance of caution due to the potential devastating sequalae associated with an unidentified cervical spine injury.

The scoring system for case specific modifiers can also be seen in Table 5, and include 2 points for a suspected disruption of the posterior capsuloligamentous complex (PLC) (M1) and 4 points for both a critical disc herniation (M2), defined as any resulting spinal cord impingement, or a metabolic bone disease or associated spine stiffening condition (M3) because both modifiers had the same injury severity rating. The M4 modifier indicates an associated vascular/vertebral artery abnormality and is not applicable to this scoring algorithm as it does not play a role in the specific surgical decision-making process for the spine injury.

Discussion

The AO Spine Subaxial Cervical Spine Injury Classification System was proposed in an effort to succeed where previous classification systems exhibited deficits.[7] Although it addresses many of the shortcomings associated with previous classification systems, namely issues with reliability and clinically relevant distinct injury morphologies, it alone is not sufficient to alter practice management as it currently only allows treating physicians to describe common injuries.[4,7-10,24] Therefore, similar to the AO Spine TLICS, this system needs to have an accompanying scoring system, driven by globally derived consensus, in order to guide treatment.[16] As such, the AO Spine Cervical Classification Validation Group, comprised of several spine surgeons with expertise in spinal trauma, analyzed the injury severity data to generate the Subaxial AOSIS system.[19] While there will always be skepticism when treatment

guidelines are not supported by level-1 evidence, many clinical situations simply have a paucity of literature surrounding their treatment guidelines. Furthermore, randomized controlled trials would be unethical in fractures that are clearly unstable and would place the patient at risk of neurologic injury. In these situations, expert consensus, especially when they are derived from a global community, offers guidance in the form of a collective opinion, where none previously existed. In fact, some of the most commonly used and widely accepted classifications systems, like the Glasgow Coma Scale, have foundations built upon expert opinion.[25-27]

While the Subaxial AOSIS system is derived from the relative injury severity ratings assigned to them by survey respondents, exact score designation was relegated to a comparatively small number of surgeons, as previously described.[19] As such, in situations where the severity ratings did not clearly delineate a relative score, clinical reasoning was applied. For example, the transition between N2 and N3 of the neurologic status subtype represents a significant functional change clinically and as such was accompanied by a 2-point score increase to match the 20-point injury severity rating increase. Conversely, in the transition from A4 to B1 injury morphologies, there was little difference between the injury severity ratings assigned to each subtype, thus their assigned score could theoretically resemble either an A3 or a B2 injury. In this situation the decision was made to have their score more closely resemble a B2 injury, even though their severity ratings were closer to an A3 injury, because of the significant instability associated with complex vertebral column pathology, as seen in A4, B1, and B2 injuries, relative to the isolated single endplate pathology associated with A3 injuries. Lastly, with regard to assigning a neurological status score for patients that are unable to provide a complete assessment, the decision was made to assign these patient a score of 3 for neurological status, which represents extreme caution. As noted by Kepler and colleagues during their generation of the scoring system for the AO Spine TLICS, any patient that is unable to provide an exam is likely a polytrauma patient in need of prompt stabilization in an effort to prevent possible irreversible negative neurological sequelae.[16]

The injury severity ratings used to generate the Subaxial AOSIS system above was derived from a survey administered to surgeons from around the world.[19] Despite associated geographic differences, and the accompanying experience differences among participants, there was very little disagreement when it came to assigning severity rating for the AO Spine SCICS subgroups and their subtypes.[19] In fact, after subgroup analysis adjustments, only B1, F2, and F3 morphological injury patterns, along with N3 neurological status and M2 modifier, differed between the almost 200 surgeons who participated in the survey.[19] Therefore, the point system that is based on these injury severity ratings will likely enjoy widespread adoption as it closely reflects the global perception of the injury severity associated with each of the AO Spine SCICS subgroups. While validation and implementation of the scoring system is the appropriate next step in the process, establishing treatment guidelines is the final goal.

Utilizing the scoring system outlined above, along with further investigation into the global trends in treatment, will further aid in the generation of these management guidelines. Similar to the injury severity ratings, this process will need to involve a global community because of the significant variation in treatment that currently accompanies these injuries. Any recommendations put forth will not only need to account for variations in treatment, but also resource availability and cultural differences.[16] While these recommendations would be subject to both objective and subjective input, they would ideally provide a solid foundation for future high-level studies.

There were several limitations associated with this prospective survey study. First and foremost, the surgeons that completed the severity surveys were not evaluated on their knowledge of spinal trauma. As such, surgeons with limited knowledge could have reasonably filled out the survey and skewed the results. This issue was addressed via our inclusion of a large number of surgeons to diminish the impact that a single surgeon could have on the data; albeit this still represents a small proportion of the global spine community. Furthermore, these surgeons represent an uneven geographic distribution and therefore their opinions may not accurately reflect those surgeons from underrepresented regions. Additionally, the scores assigned to each subgroup in the AO Spine SCICS were entirely arbitrary, only representing a perception of associated injury severity, which seemingly progressed in a relatively positive stepwise manner, with a few exceptions, and thus were most commonly assigned a single additional point accordingly. Prospective evaluation of injured patients using this points scheme will provide insight into the relative accuracy, and possible need for revision, of the Subaxial AOSIS system for delineating surgical thresholds. Similar to the development of the AO Spine TLICS scoring system, surgical thresholds will be established based on questionnaires designed to distinguish which AO Spine SCICS subgroups are thought to require surgical stabilization and or decompression.

Conclusion

The hierarchical scoring system proposed in this article represents the global perception of injury severity associated with each of the AO Spine SCICS subgroups and modifiers. The severity ratings assigned to each subgroup had little geographic or experiential variability and thus serve as a foundation on which to build the Subaxial AOSIS system, particularly given the documented reliability of the AO Spine SCICS. These results suggest that the AO Spine SCICS and its outlined scoring system represents a unique opportunity for the development of a universally accepted treatment algorithm for subaxial cervical spine traumatic injuries.

Authors' Note

All authors significantly contributed to the document and have reviewed the final manuscript. This clinician survey study was exempt from Institutional Review Board review. AO Spine Cervical

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