

## Can Injury Type/ Subtype of the New Aospine Subaxial Cervical Trauma Classification Dictate Patient's Treatment?

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### ABSTRACT

**AIM:** The AOSpine Subaxial Cervical Classification (AOSCC) was proposed in 2015 to review and improve morphology aspects of cervical fractures classification. The main objective of this paper is evaluate if the new AOSCC can predict non-surgical versus surgical management of traumatic cervical injuries.

**MATERIALS AND METHODS:** The AOSCC was retrospectively applied in a retrospective case series of 51 patients with subaxial cervical spine trauma (C3-7) treated according to the SLICS system by a single surgeon. The type, subtype and facet modifier were correlated with non-surgical versus surgical treatment using the t-student and Chi-Square tests.

**RESULTS:** Most of these patients were men (88.2%), suffered car

accidents (33.3%) with a median SLIC score of 4.52 points. There was no neurological deterioration in this series. In the non-surgery group, nineteen patients (95%) were classified as type A fractures, whereas only one patient (5%) had a type C injury not surgically treated due to severe concomitant clinical complications and traumatic brain injury. In the surgically treated group, fifteen patients (48.3%) were classified as type C. The A0 group was associated to non-surgery group ( $p = 0.0005$ ) and the B-C groups was significantly associated to surgery group ( $p = 0.0006$ ). The F1-2-3 was associated to non-surgery group ( $p = 0.0102$ ) and F4 modifier to surgery group ( $p = 0.0006$ ).

**CONCLUSION:** Some injury patterns may predict surgical treatment, such as type C characterized by cervical dislocations. Type A injuries, despite a potential for bone healing, may require additional radiological investigation in the setting of neurological deficits, to define the best treatment modality.

**Key words:** Subaxial Cervical Spine; Trauma; Classification; Surgery

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### INTRODUCTION

The new AOSpine Subaxial Cervical Spine Trauma Classification (AOSCC) proposed by Vaccaro et al in 2015<sup>[1]</sup>, was created to improve the reliability and clinical use of the previous classification systems, such as the proposed by Magerl et al<sup>[2]</sup> The International AO Spine Trauma Knowledge Forum had validated this new classification in some reliability studies<sup>[3-6]</sup>, suggesting potential relevance to clinical practice and in the treatment decision.

Schnake et al. in 2017, reviewed the classification applying 40 cases to 9 spine experts to classify the fractures with the new AOSCC. The results were analyzed by the Kappa index to determine the reliability of the answers between observers. The inter-observer index was  $K=0.64$  and intra-observer was  $K=0.75$  that represents a substan-

tial agreement. Similar results were found by Vaccaro et al. in 2015 in the AO Spine validation study. Silva et al in 2016 and Urrutia et al in 2017, found similar results to these studies, however both studies the extreme divisions A0 and C were found the better agreement, however the intermediate subdivisions as A3/A4/B1/B2/B3 had a poor index between observers.

This classification is divided in four main aspects: Vertebrae morphology, facet morphology, neurologic status and additional modifiers (Table 1). Vertebral morphology is divided in three groups considering mechanical impact factors: A - compression fractures, B - distraction injuries, C - rotational/translational injuries. Type A is then subdivided in five subtypes: A0 - no vertebral body, minor fracture, laminae fracture, transverse or spinal process fracture, A1 - single end plate fracture, A2 - both end plates fracture (split vertebrae) (without burst), A3 - single end plate involvement burst fracture (posterior vertebral body wall broken), A4 - both end plates burst fracture or complete burst fracture. Type B injuries are divided in: B1 -posterior bone lesion (Chance’s fractures), B2 - posterior capsular ligamentous injuries, B3 - anterior tension band lesion (generally associated with osteophytes). Finally, type C group injury had no subtypes. Facet modifiers are presented in table 1, with four subtypes. Neurological status (N) is also evaluated, considering patients as intact, with incomplete or complete deficits, radiculopathy or transient neurological deficits. Finally, special modifiers (M) were proposed to influence the final treatment guidance: M1 - posterior capsuloligamentous lesion without disruption, M2 - Critical disk herniation, M3 - Stiffening metabolic disease (DISH/AS), M4 - vertebral artery abnormally.

Considering the lack of studies of this new system, we designed this retrospective study to evaluate if the AOSCC type and subtype were enough to guide surgical versus non-operative management of cervical spine traumatic injuries.

## MATERIALS AND METHODS

Patients with subaxial cervical trauma(C3 to C7) treated in our institution were included. All data was collected retrospectively after Institutional Review Board Approval (CAAE 43716615.2.0000.5404). Part of this data was part of a study assessing the reliability of the AOSCC system<sup>[5]</sup>.

All patients’ treatment was conducted by a single surgeon (AFJ) who had expertise in Spine Trauma Management. To guide the surgical treatment, the Subaxial Cervical Injury Classification Score (SLICS)<sup>[7]</sup> was used. However, patients with less than 4 points were treated non-surgical and patients with 4 or more points were treated surgically (which includes those with four points). Also was applied the ASIA Impairment Scale (AIS), that is described in table 2.

Patients of our database were then retrospectively classified according to the AOCC by the treating surgeon using imaging obtained in DICOM format by Aurora PACS 2, Pixeon ®. The AOSCC is presented in table 1.

Patients younger than 14 years or with incomplete radiologic and clinical data were excluded.

The evaluation of the differences between the groups Surgery and non-Surgery was made by using of t-student test for quantitative variables (age). For the qualitative variables, presented by absolute and percentual (%) frequencies, was used the Chi-Square test. A significance level of 5% was used and all analysis was realized in a R-Gui ambient. (R CORE TEAM. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. 2018. Available in <http://www.R-project.org/>).

To the statistical analysis, the morphologies were separated in 5 groups: A0, A1-2-3-4 and B-C, F1-2-3 and F4 based on Magerl con-

**Table 1** The new AOSpine Subaxial Cervical Classification(AOSCC)<sup>[1]</sup>.

Vertebral Morphology	Facet Morphology
A Compression injury	F1 - no displacement - < 1cm, <40%
A0 - no bone lesion / minor fracture	F2 - >1cm, >40% or displacement
A1 - single plate compression	F3 - floating lateral mass
A2 - “split vertebrae”, both plate fracture	F4 - subluxation or perched
A3 - single plate burst	BL - bilateral injury
A4 - both plates burst	
B Tension band injuries	
B1 - posterior tension band injury (bone)	
B2 - posterior tension band injury(capsuloligament)	
B3 - anterior band injury	
C Rotation / Translational injuries	

**Table 2** ASIA Impairment Scale.

Grade	Definition
A	Complete. No sensory or motor function is preserved in the sacral segments S4-S5
B	Incomplete. Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-S5
C	Incomplete. Motor function is preserved below the neurological level, and more than half of key muscles below the neurological level have a muscle grade less than 3 (Grades 0-2).
D	Incomplete. Motor function is preserved below the neurological level, and at least half of key muscles below the neurological level have a muscle grade greater than or equal to 3.
E	Normal. Sensory and motor functions are normal.

**Table 3** Non-Surgery Group.

N	Sex	Age	Mechanism	SLICS	AIS	Complications	M	F
1	M	24	Car accident	1	E		A0	F2
2	M	51	Motorcycle	0	E		A0	
3	F	38	Aggression	1	E		A0	
4	M	75	Car accident	1	E		A0	F2
5	M	22	Fall	0	E		A0	F2
6	M	30	Car accident	0	E	Head trauma	A0	F1
7	F	24	Motorcycle	0	E	Head trauma	A0	F1
8	M	29	Car Accident	0	E	Listhesis	A0	F2
9	M	54	Car Accident	3	C		A0	F1
10	M	19	Motorcycle	0	E		A0	
11	M	47	Fall	0	E		A0	
12	F	42	Running over	0	E		A3	
13	M	30	Car accident	0	E		A0	F2
14	M	43	Motorcycle	2	A		A0	
15	M	64	Car accident	7	C		C	F4
16	M	66	Fall	0	E		A0	F1
17	M	17	Aggression	0	E		A0	
18	M	49	Car accident	0	E		A1	
19	M	37	Aggression	4	C		A0	
20	M	31	Motorcycle	0	E		A0	

cepts of severity and stability.

## RESULTS

Fifty-one patients were included. Forty-five patients (88.2%) were male and six (11.2%) were female. The median age of this patients was 39.29 years-old (ranging from 17 to 82 years-old). The main mechanism of trauma was car accident with 33.3% of the cases. The median SLIC score 4.52 points (ranging from 0 to 11, mean of 4.52).

### Non-surgically managed group

There were 20 patients treated non-surgically. All of them had a cervical collar prescribe for 8 to 12 months. Seventeen patients (85%) were male and had a median age of 39.4 years old. The median fol-

low-up was up to 86.8 days. The median SLICS was 1 point (range from 0 to 7). Sixteen (80%) patients were neurologically intact, but four patients (20%) had neurologic damage (AIS A and C) despite of a stable cervical spine and no evident compression.

There were 17 patients classified as subtype A0 (85%), one patient with A1 (5%) and one patient with A3 (5%). There was a patient with type C injury (5%) treated non-surgically due to a severe neurological deficit due a traumatic brain injury and clinical comorbidities, with a long hospital permanence. After 3 months, this patient had consolidated fracture and with stablished neurological deficit (AIS C) and non-surgical treatment was maintained.

Ten patients had no facet fracture (50%), four patients (20%) had F1 facet modifier, five patients had F2 (25%) facet modifier and one patient with F4 (5%) (the one with Type C injury) (Table 3).

**Surgically managed group**

There were thirty-one patients who had underwent surgical treatment, twenty-nine patients were men(90.3%)and a median age of 39 years old.

The SLICS median was 6.67 points (ranging from 4 to 11). Before the surgery there were nine patients with neurological deficits that improved during the follow-up. Six patients without deficits had surgery and all had a type C fracture.

Eleven patients were classified as subtype A0 (35.4%), four patients with A4 (12.9%), one patient with B2 (3.2%) and fifteen pa-

tients as type C (48.3%).Seven patients (22.5%) with minor lesion on CT Scan (A0), were operated after MRI due to critical disc herniation (M2).

Eleven patients had no facet fracture (35%), two patients had F1 (6.4%), two patients had F2 (6.4%) and sixteen patients (51.6%) had F4 morphology. All patients with type C injuries had a F4 facet modifier (Table 4). We had no type F3 injury in our study.

**Statistical Analysis**

**Table 5** Demographic characteristics.

Group	Total	Surgery	Non-Surgery	p-value
Age	39.3±15.4	39.1±14.9	39.6±16.5	0.911
Male (%)	45 (88.2)	28 (90.3)	17 (85.0)	0.565
Traffic Accident(%)	26 (51.0)	17 (54.8)	9 (45.0)	0.493
Total of Patients	51	31	20	

**Table 6** Vertebrae Morphology Classification.

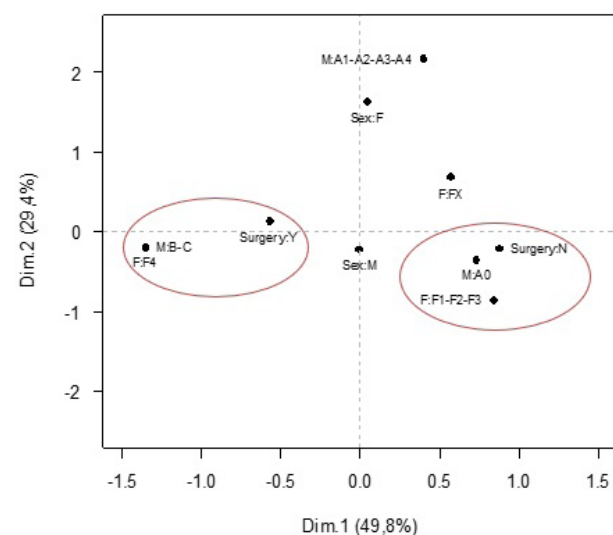
Group	Total	Surgery	Non-Surgery	p-value
A0	28 (54.9)	11 (35.5)	17 (85.0)	0.001
A1-A2-A3-A4	6 (11.8)	4 (12.9)	2 (10.0)	0.753
B-C	17 (33.3)	16 (51.6)	1 (5.0)	0.001
Total of Patients	51	31	20	

**Table 7** Facet modifiers.

Group	Total	Surgery	Non-Surgery	p-value
F1-F2-F3	13 (25.5)	4 (12.9)	9 (45.0)	0.010
F4	17 (33.3)	16 (51.6)	1 (5.0)	0.001
No Facet Fracture	21 (41.2)	11 (35.5)	10 (50.0)	0.304
Total of Patients	51	31	20	

**Table 4** Surgery group.

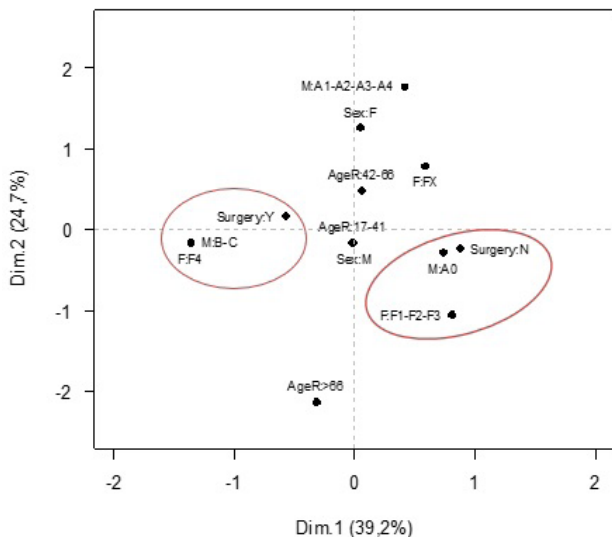
N	Sex	Age	Mechanism	SLICS	AIS	Complications	M	F
1	M	23	Car accident	8	A	Respiratory	C	F4
2	F	48	Car accident	7	E	Infection	C	F4
3	M	27	Car accident	7	A		C	F4
4	M	23	Sports practice	6	E		C	F4
5	M	65	Car accident	9	C		C	F4
6	M	56	Colision	7	E		C	F4
7	M	20	Diving	7	D		A4	
8	M	43	Car accident	4	C		A0	
9	M	27	Car accident	9	D		A0	F2
10	M	32	Diving	6	C	Chronic pain	C	F4
11	M	65	Colision	6	C		A0	
12	M	40	Car accident	5	C		A0	
13	M	23	Fall	6	E		C	F4
14	M	51	Fall	5	C		A0	
15	M	46	Motorcycle	5	E		C	F4
16	M	40	Motorcycle	4	A	Sepsis	A0	
17	M	82	Fall	9	B		C	F4
18	M	42	Car accident	6	B		A0	
19	M	39	Car accident	10	A		C	F4
20	F	24	Motorcycle	6	A		A4	
21	M	33	Car accident	4	C		A0	F1
22	F	18	Car accident	4	E		B2	F4
23	M	45	Fall	4	C		A0	
24	M	30	Car accident	6	A	Respiratory	A4	
25	M	33	Car accident	7	A	Sepsis	C	F4
26	M	29	Motorcycle	8	A		A0	F1
27	M	39	Diving	6	C		A4	F2
28	M	58	Aggression	6	E		A0	
29	M	34	Diving	10	B		C	F4
30	M	33	Aggression	9	B	Respiratory	C	F4
31	M	44	Fall	11	D		C	F4



**Figure 1** Multiple correspondence analysis, considering the variables: "Mo", "F", "Sex", "Surgery (Y/N)"

**DISCUSSION**

The new AOSCC is based on the new AO system proposed for Thoracolumbar trauma derived from the previous Magerl<sup>[2]</sup> classification system. Magerl et al. proposed that spinal fractures should be divided in 3 different groups according to their mechanisms of trauma in A, B and C, with increasing progressive degrees of instability. The new system had subclassifications to improve morphology description as well as facet modifiers, neurological status (similar to the SLICS system) and special modifiers.



**Figure 2** Multiple correspondence analysis, considering the variables: "M", "F", "Sex", "Surgery (Y/N)" e "Age".

The A (compression) lesions were considered “benign” with mild bone injuries, whereas type B (tension band injuries) and C (rotational lesions) had more potential to instability.

Aarabi *et al*<sup>[8]</sup> in 2017, evaluated a series of 92 patients, who had severe neurological deficits, correlating morphology class with the severity, by the age, ASIA motor score, injury severity score, intramedullary lesion length and the AIS conversion in the follow up. In his analysis, were evident that the new AOSpine classification follows a severity sequence and can predict the severity and chances of neurological recovery. Patients who had C lesion had severe intramedullary lesion length than B patients with less potential of neurological recovery ( $p < 0.02$ ).

Another series, published in 2017 by Vaněk<sup>[9]</sup>, reported 48 patients were treated using the new AOSpine classification during a period of 2-years. Eleven patients with A0/A1 F1 were treated conservatively and the other 37 patients with A3/4 B and C morphology were treated surgically, with inter-observer agreement of each group of morphology in 89.3% of cases. Despite our study, in this series had 3 patients with F3 lesion (6.3%) which underwent in surgery.

In our series, most of non-surgically treated (85%) had A0 injury subtype and were neurologically intact, with statistical significance ( $p = 0.0005$ ). Only one patient of non-surgery group was a type C lesion that initially should have been operated but due to a severe traumatic brain injury and systemic complications were managed non-operatively. The facet morphologies F1-2-3 were statistically associated to non-surgery group ( $p = 0.0102$ ) and potentially stable lesions.

Differently, in the surgically managed group, all patients with type C injury (48.3% of all cases in the surgical group) were operated, despite some of them are neurologically intact. In these latter cases, the spine was considered potentially unstable due to misalignment. All patients with a type C injury had a F4 facet modifier, which means that is redundant to classify the facet modifier in type C morphologies. Statistically the B-C group and F4 modifier had an association to surgery in both occasions ( $p = 0.0006$ ). In observation, the male individuals and the age between 17 to 41 years old had an association to surgery group in multiple correspondence analysis.

Du *et al*<sup>[10]</sup>, reported in 2019, a series of 402 patients were underwent surgery, there is an evidence that B and C/F4 lesions that receive early surgery has better neurological outcomes. Lesions with A/F1-3 have not differences in outcomes if the surgery was delayed to MRI realization<sup>[10]</sup>.

In our study, all cases with subtype A4 (burst fractures), a total of four cases, were surgically treated due to neurologic impairment. However, seven patients (22.5%) had no evident bone fractures (AO) and required an MRI to detected persistent compression due to degenerative changes exacerbated in the trauma context and were surgically treated. By this reason, in the setting of neurological deficits and mild bone fractures, the CT scan based AOSCC is not enough to guide surgical management.

Our study is limited by its retrospective nature and for being a single center, single surgeon study. However, it provides some guidance in the use of the new AOSCC in the treatment of subaxial cervical spine trauma, which may be useful for new prospective studies.

## CONCLUSION

We reported that type C injuries were surgically managed in most of the cases and the classification of the facet modifier as F4 is redundant in this context. Additionally, mild bone fractures (such as type A0) in the setting of neurological deficits requiring an MRI, which provides limited value to the fracture severity degree of the new AOSCC. Further studies are necessary to evaluate the treatment performed in less prevalent subtype (such as type B injuries).

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