

# Is There an Association With Spino-Pelvic Relationships and Clinical Outcome of Type A Thoracic and Lumbar Fractures Treated Non-Surgically?

ANDREI FERNANDES JOAQUIM, MD, PHD,<sup>1</sup> SÉRGIO AUGUSTO RODRIGUES, PHD,<sup>2</sup> FELIPE SOARES DA SILVA,<sup>1</sup> OTÁVIO TUROLO DA SILVA, MD,<sup>1</sup> ENRICO GHIZONI, MD, PHD,<sup>1</sup> HELDER TEDESCHI, MD, PHD,<sup>1</sup> GREGORY D. SCHROEDER, MD,<sup>3</sup> ALEXANDER R. VACCARO, MD, PHD, MBA,<sup>3</sup> ALPESH A. PATEL, MD, FACS<sup>4</sup>

<sup>1</sup>Department of Neurology, Neurosurgical Division, State University of Campinas–UNICAMP, Campinas-SP, Brazil, <sup>2</sup>Department of Bioprocess and Biotechnology, State University of São Paulo–UNESP, Botucatu-SP, Brazil, <sup>3</sup>Department of Orthopaedic Surgery, The Rothman Institute at Thomas Jefferson University, Philadelphia, Pennsylvania, <sup>4</sup>Department of Orthopedics, Northwest University, Chicago, Illinois

## ABSTRACT

**Background:** The objective was to evaluate if there is an association of the spino-pelvic relationships and the global spinal alignment with the outcome of AO type A injuries treated nonsurgically.

**Methods:** This is a retrospective case series. Patients treated nonsurgically for AOSpine type A fractures (T1-L5) with at least 1 year follow-up identified. A standing antero-posterior and lateral 36-inch radiographs and measures of spino-pelvic relationships and sagittal alignment were obtained, as well as clinical assessment using the visual analog scale, the Short-Form 36 (SF-36) questionnaire, the Oswestry Disability Index (ODI), and labor status.

**Results:** Twenty-two patients with 33 fractures were included (L1 was the most injured level with 18.2%). There were 17 men (77.2%) and the mean age was 47.1 years. Follow-up ranged from 12 to 60 months (mean of 27.8 months). There were 22 type A1 (66.7%), 3 type A2 (9%), 6 type A3 (18%), and 2 type A4 (6%) fractures. The ODI ranged from 4% to 58%, with a mean of 24.4%. The SF-36 physical health score ranged from 23 to 82.25 (mean 49.59), and the mental health score ranged from 14.75 to 94.25 (mean 63.28). No association was identified between the spino-pelvic measurements, global alignment, and patient-reported outcomes.

**Conclusions:** Type A fractures had a clinically relevant amount of long-term disability even when surgical treatment is not required. Spino-pelvic relationships and final global spinal alignment did not associate with outcome measurements.

Lumbar Spine

Keywords: thoracolumbar, compression, burst, fractures, conservative treatment, outcome, sagittal balance, spino-pelvic relationships, VAS, ODI, SF-36, TLICS

## INTRODUCTION

Thoracic and lumbar fractures are the most common site of spinal fractures. These mainly involve the thoracolumbar junction (T11 to L2), as it is a transitional area between the rigid thoracic and the mobile lumbar spine.<sup>1,2</sup> Vaccaro et al<sup>3</sup> and the AOSpine Trauma Knowledge Forum recently proposed a new classification with 3 major types: type A–compression injuries (including burst fractures), type B–lesions with anterior and/or posterior tension band injury, and type C–translation injuries.<sup>3</sup> While there is no universally accepted treatment algorithm for A3 (burst fractures involving the posterior vertebral wall and a single endplate) and A4 fractures (burst fractures involving the posterior

vertebral wall and both endplates), most commonly type A injuries without neurological deficits may be managed without surgery, with a low risk of late neurological deterioration.<sup>2,4,5</sup>

While the short-term results of nonsurgical fracture management are known, the long-term outcomes of such treatment remain uncertain.<sup>1</sup> Nonsurgical treatment may yield residual deformity which, in turn, may lead to sagittal imbalance, pain, or functional disability. Furthermore, the effects of spino-pelvic relationships on these outcomes remain uncertain. The objective of this study is to determine the functional outcomes of patients with type A fractures treated nonsurgically and their association

**Table 1.** Functional outcome measurements performed in the 22 patients included in our current study.

	Range	Median	Mean	Standard Deviation
Total ODI	4% to 58%	22%	24.4%	17.7%
SF-36 physical component	23 to 88	49.5	49.6	19.2
SF-36 mental component	14.8 to 94.2	58.4	63.3	21.9
Pain status (VAS)	0 to 9	4.00	4.68	2.57

Abbreviations: ODI, Oswestry Disability Index; SF-36, Short-Form 36; VAS, visual analog scale.

with global spinal alignment and spino-pelvic relationships.

## METHODS

After institutional review board approval, 46 patients with type A fractures treated nonsurgically at a single, tertiary institution were retrospectively identified through a prospectively collected database. All patients were contacted by telephone. Twelve patients were not found: 2 had died of nonrelated causes, 2 refused to participate, and 8 could not be found by any means. Thirty-four patients agreed to participate in the study: 27 completed questionnaires and 22 underwent a new radiological evaluation and were included in the study. Patients without radiographic follow-up, those with pathological fractures, as well as patients with symptomatic previous degenerative spine diseases, patients with amputation in any limb, poor mental status, or with traumatic brain injury with cognitive or physical sequels were all excluded.

Of note, conservative treatment of the fractures consisted in the following: an external orthosis according to the involved level for about 3 months, followed by prescription of pain medication with ambulation permitted but all other physical activities restricted. Plain radiographs were generally obtained after 2 weeks, 1 month, 3 months and, then, every 6 months to assess bone healing or progressive deformity/instability. Patients were all treated and followed at the same institution (blinded for review) by the same spine surgeon (blinded for review).

Patient-reported outcome measures included 2 surveys performed at the last patient visiting: (1) the Oswestry Disability Index (ODI) (Table 1), and (2) the Short-Form 36 Health Survey Questionnaire (SF-36) mental and health status, both with validated versions in Portuguese.<sup>6-8</sup> The ODI interpretation used was as follows: (1) 0% to 20.99%—the patient can cope with most living

activities. Usually no treatment is indicated apart from advice on lifting sitting and exercise; (2) 21% to 40.99%—the patient experiences more pain and difficulty with sitting, lifting, and standing. Travel and social life are more difficult and they may be disabled from work. Personal care, sexual activity, and sleeping are not grossly affected, and the patient can usually be managed by conservative means; (3) 41% to 60.99%—pain remains the main problem in this group but activities of daily living are affected. These patients require a detailed investigation; (4) 61% to 80.99%—back pain impinges on all aspects of the patient's life. Positive intervention is required; (5) and 81% to 100%—these patients are either bed-bound or exaggerating their symptoms.

The SF-36 had a scale ranging from 0 to 100, when 0 is the worst and 100 is the best functional score.

Additionally, we assessed the visual analog scale (VAS) for back pain. We asked patients to evaluate their mean degree of pain in the fracture region in the last month, by giving it a score of 0 to 10 points (being 0 no pain, and 10 the most severe pain). We also questioned them about their working status at the time we performed the interview.

Fractures were radiographically classified according to the new AOSpine classification in type A1 to A4 based on the computed tomography (CT) scan obtained immediately after spine trauma.<sup>3</sup> The classification was performed by the one of the authors (blinded for review), who had previous experience in spinal trauma classification studies and was blinded from the results of treatment. Radiological measurements performed with a standing plain 36-inch x-ray in antero-posterior and lateral views were as follows: (1) global sagittal alignment (C7-SVA), (2) pelvic tilt (PT), (3) pelvic incidence (PI), (4) lumbar lordosis (LL from L1 to S1), thoracic kyphosis (TK from T5 to T12), (5) kyphosis of the fracture(s) segment, measured through the Cobb angle from the disc above from the disc below the most severe fracture(s) level, and kyphosis of the adjacent fracture segment, measured as the Cobb angle from 1 level above and 1 level below the most severe fracture(s) level, (6) canal compression (for type A3 and A4 fractures), the antero-posterior diameter of the most compressed site was compared with the normal diameter of the same vertebra estimated by the edges of both pedicles using CT scan images.

**Table 2.** Radiological measurements performed in the 22 patients included in our current study.

Measurement	Mean	Median	Range	Standard Deviation ±
Pelvic tilt	15.35°	17.50°	0 to 27	7.84
Pelvic incidence	48.18°	45°	24 to 85	16.17
PI – LL	8.38°	7.5°	–32 to 67	20.82
C7-SVA	1.31 mm	3.68 mm	–52 to 34	25
Thoracic kyphosis	35.11°	33°	6 to 55	13.6
Lumbar lordosis	39.86°	41.5°	18 to 63	14.51
Kyphosis of the most severe fracture(s) level	15.27°	15°	2 to 35°	9.36
Kyphosis of the most severe segment fractured (1 level above and 1 level below)	14.46°	12°	1 to 34°	9.7
Canal compression*	25.1%	0	0% to 83.3%	34.4

Abbreviations: PI, pelvic incidence; LL, lumbar lordosis; C7-SVA, global spinal alignment.  
 \*Only 8 fractures had canal compression (6 A3 and 2 A4).

The radiological measurements were also performed by the senior surgeon (AFJ) using the PACS Aurora database and DICOM images. PI – LL mismatch was also calculated. The statistical analysis was performed using a Pearson correlation test and the Kruskal-Wallis nonparametric test with a significance defined as  $P < .05$ .

## RESULTS

There were 17 men (77.2%) and 5 women (22.8%) in our study, with ages ranging from 21 to 70 years old (mean of 47.1 years). The main trauma mechanism was fall from the height in 50% of the cases. The follow-up ranged from 12 to 60 months (mean of 27.8 months).

The mean VAS score obtained at the last follow-up was 4.6 points, ranging from 0 to 9 points (Table 1). Six patients (27%) did not return to work after trauma, one due to a fracture of the lower limb. Excluding this patient, 22.7% (5 of 22 patients) did not return to normal work after spinal trauma. There were 9 patients with a VAS of 0 to 3 points (40.9%), 5 patients had a VAS from 4 to 6 points (22.7%), and 8 patients had a VAS of 7 or more points (36.3%).

The ODI ranged from 4% to 58%, with a mean of 24.4% (Table 1). There were 10 patients (45.5%) with minimal disability (0% to 20%), 7 patients (31.8%) with moderate disability (21% to 40%), and 5 patients (22.7%) with severe disability (41%

to 60%). Interestingly, of the 5 patients with severe disability, only 2 (40%) did not return to work.

The SF-36 (Table 1) for physical health ranged from 23 to 82.25 (mean 49.59), and for mental health it ranged from 14.75 to 94.25 (mean 63.28).

Eleven patients (50%) were performing routine physical activities by the time of our clinical assessment. Five patients reported pain when performing any activity, such as mild walking (22.7%), and the remained patients did not want or did not explain the reason for being inactive.

### Fractures Characteristics

There were 33 fractures in the 22 patients included in our study. One patient (4.5%) had 4-level fractures, 2 patients (9%) had 3-level fractures (13.6%), and 4 patients (18%) had 2-level fractures. Fifteen patients had only 1 fracture, with a total of 33 fractures. The most injured level was L1 (6 cases, 18.2%), followed by L2 (5 cases, 15.1%), T12 (4 cases, 12.1%), L3 and L4 (3 cases, 9%), T5, T11 and L5 (2 cases, 6%), and T3, T4, T6, T7, T9, and T10 with 1 case each (3%). There were 22 type A1 (66.7%), 3 type A2 (9%), 6 type A3 (18%), and 2 type A4 (6%) fractures according to the new AOSpine classification system. The thoracolumbar injury classification system (TLICS of the most severe fracture of each patient ranged from 1 to 4 (mean 1.6 points). Only 2 patients had a TLICS of 4 points.

**Table 3.** Correlation of the outcome measurements (Oswestry Disability Index [ODI], Short-Form 36 [SF-36] physical component and SF-36 mental status) with the radiological measurements performed in our study ( $P$  value using a Pearson correlation test).

	Number of Fractures	PT	C7-SVA	TK	PI	LL	PI – LL	Kyphosis of the Vertebra	Kyphosis of the Segment	Canal Compression
Total ODI	0.432	0.914	0.478	0.879	0.471	0.725	0.835	0.938	0.198	0.915
SF physical	0.924	0.793	0.812	0.515	0.079	0.413	0.489	0.837	0.555	0.695
SF mental	0.823	0.584	0.721	0.230	0.113	0.153	0.887	0.631	0.609	0.002
Pain	0.599	0.681	0.758	0.994	0.140	0.722	0.360	0.915	0.206	0.562

Abbreviations: PT, pelvic tilt; C7-SVA, global spinal alignment; TK, thoracic kyphosis; PI, pelvic incidence; LL, lumbar lordosis.

**Table 4.** Correlation of the Oswestry Disability Index (ODI) with the radiological measurements performed in our study (*P* value using a nonparametric test of Kruskal-Wallis).

Measurement	ODI			P Value
	1 (0% to 20.99%)	2 (21% to 40.99%)	3 (41% to 60.99%)	
PT				
Mean (SD)	15.7 (7.4)	14.4 (9.9)	16.0 (7.0)	
Median (Q1–Q2)	17.4 (9.1 to 20.7)	17.0 (7.0 to 21.5)	18.0 (15.0 to 18.0)	.995
C7-SVA				
Mean (SD)	1.1 (24.2)	−9.45 (31.2)	16.8 (12.7)	
Median (Q1–Q2)	4.0 (−7.5 to 14.5)	0.0 (−29.3 to 3.7)	14.0 (13.0 to 23.0)	.186
TK				
Mean (SD)	37.7 (12.5)	30.7 (15.8)	36.2 (14.0)	
Median (Q1–Q2)	36.0 (31.8 to 48.5)	31.0 (23.5 to 38.0)	31.0 (29.0 to 32.0)	.621
PI				
Mean (SD)	52.1 (18.8)	42.9 (17.8)	47.8 (3.3)	
Median (Q1–Q2)	48.0 (38.8 to 60.8)	40.0 (30.5 to 50.5)	49.0 (45.0 to 49.0)	.396
LL				
Mean (SD)	42.4 (14.8)	36.0 (16.1)	40.2 (13.5)	
Median (Q1–Q2)	46.5 (39.5 to 50.8)	29.0 (24.5 to 50.0)	34.0 (31.0 to 42.0)	.736
PI7 – LL				
Mean (SD)	8.7 (25.8)	8.3 (19.8)	7.6 (14.0)	
Median (Q1–Q2)	4.0 (−3.0 to 14.0)	9.0 (−1.0 to 18.0)	10.0 (3.0 to 18.0)	.946
Kyphosis of the most affected level				
Mean (SD)	12.5 (10.1)	19.3 (9.4)	10.4 (7.8)	
Median (Q1–Q2)	8.7 (6.0 to 13.5)	23.0 (11.5 to 27.5)	12.0 (4.0 to 15.0)	.205
Kyphosis of the most affected segment				
Mean (SD)	17.2 (11.1)	14.7 (9.5)	12.2 (5.4)	
Median (Q1–Q2)	16.0 (6.8 to 26.5)	16.0 (7.0 to 23.0)	12.0 (11.0 to 16.0)	.626
Canal compression				
Mean (SD)	25.6 (33.3)	30.4 (38.3)	16.7 (37.3)	
Median (Q1–Q2)	0.0 (0.0 to 59.8)	0.0 (0.0 to 66.5)	0.0 (0.0 to 0.0)	.823

Abbreviations: PT, pelvic tilt; C7-SVA, global spinal alignment; TK, thoracic kyphosis; PI, pelvic incidence; LL, lumbar lordosis.

In Table 2, we presented the radiological characteristics measured in the 22 patients included in this study. Using the Pearson correlation test, there was minimal correlation between any of the radiographic measurements and the SF-36 physical component score, the SF-36 mental component score, the ODI, and the VAS back pain. The only correlation obtained was with the SF mental score and the Canal Compression rate (*P* = .002); however, interpretation of this is limited, as there were only 8/33 fractures that had retropulsion. Similarly, no correlation between the ODI with the radiological measurements performed in this study was identified

using a nonparametric test of Kruskal-Wallis. In fact, there was not even a strong trend identified, with the C7 Sagittal Vertical Axis coming the closest to significance with a *P* value of .186. Any radiological measurement correlated with the ODI (Tables 3 and 4).

Finally, in Table 5, we presented the correlation of the radiological measurements. The number of fractures had association with TK (0.008) and LL (0.007), and LL had association with TK (0.000) and PI-LL (0.007). PI and LL correlates with PI-LL (0.000 and 0.001, respectively).

**Table 5.** Correlation test of radiological measurements performed in our study (*P* value after a Pearson).

	Number of Fractures	PT	C7-SVA	TK	PI	LL	PI – LL	Kyphosis of the Vertebra	Kyphosis of the Segment	Canal Compression
Number of fractures	0.000	0.572	0.445	0.008	0.660	0.007	0.160	0.060	0.200	0.848
PT		0.000	0.925	0.069	0.451	0.049	0.050	0.995	0.428	0.381
C7-SVA			0.000	0.902	0.081	0.353	0.066	0.573	0.213	0.145
TK				0.000	0.927	0.000	0.007	0.564	0.735	0.978
PI					0.000	0.723	0.000	0.843	0.805	0.607
LL						0.000	0.001	0.773	0.919	0.821
PI – LL							0.000	0.904	0.702	0.974
Kyphosis of the vertebra								0.000	0.051	0.568
Kyphosis of the segment									0.000	0.612
Canal compression										0.000

Abbreviations: PT, pelvic tilt; C7-SVA, global spinal alignment; TK, thoracic kyphosis; PI, pelvic incidence; LL, lumbar lordosis.

## DISCUSSION

In this study, we evaluated the outcome of patients with type A fractures without neurological deficits treated nonsurgically and the association of functional status and pain with global spinal alignment and spino-pelvic relationships. This is the first study that associates the outcome of spinal fractures with spino-pelvic relationships in the literature. We found that a significant portion of patients after a type A fracture have persistent disability; however, this disability is not related to spino-pelvic parameters. This finding is critical, because it suggests that it may be the injury itself, and not the change in alignment that leads to the persistent disability. Some authors argue for aggressive surgical treatment to better restore alignment, but the current study finds that there is no correlation between the final alignment and the health-related quality of life outcomes.<sup>9</sup>

In general, the epidemiology of our patient sample was similar to that of majority of trauma series found in the literature, as most of our patients were male adults with thoracolumbar junction fractures.<sup>10–12</sup> Additionally, none of our patients had late neurological deficits, suggesting that conservative treatment of type A fractures is safe when considering neurological preservation, as demonstrated in prior studies.<sup>13–15</sup>

However, while neurologically safe and effective, the mean ODI of our series was 24.39%, suggesting that type A fractures can lead to some degree of long-term disability even when surgical treatment is not required. Of note, 5 patients (22.7%) had severe disability based on ODI. This fact enforces that even mild fractures may have a tremendous impact in social and economical life of patients. Among those with severe disability, 3 patients (60%) were working by the time we performed our clinical assessment, suggesting that economical issues may also play a role in the working status despite their poor clinical condition. Five of the 22 patients did not return to work. As expected, physical health status in the SF-36 (mean 49.59) was more compromised than mental health (mean 63.28) in our patients. This is probably due to the fact that spinal trauma generally compromises previously healthy people and physical limitation may play a major role for them.

The spino-pelvic relationships evaluated, the final global spinal alignment, LL, and TK did not associate with outcome measures (ODI and SF 36

physical status) (Table 3 and 4). Furthermore, while the study is undoubtedly limited because of the small size, the results of this study did not even find a trend; therefore, it is likely that these results truly represent no correlation and are not just the result of an underpowered study. Distinct from degenerative spinal diseases and spinal deformities, clinical outcomes of spinal trauma may not be associated with these radiological measures as we hypothesized.<sup>16–18</sup> These will require further studies addressing the relationship between clinical outcome and spinal fractures treated nonsurgically.

Considering association among the radiological measurements, the total number of fractures had correlation with TK and LL, probably because more fractures may lead to more kyphosis and influencing both TK and LL as compensatory changes (Table 5). A correlation of TK and LL was observed potentially due to compensatory changes, since mild TK had generally mild LL (Table 5).

Our study is limited by its retrospective nature and small number of patients. However, we have observed, for the first time, that the outcome of patients with type A fractures treated nonsurgically did not associate with any important spinal pelvic relationship, nor global spinal alignment, nor the number of fractures. Additionally, we could report that even mild spinal trauma may lead to significant levels of patient disability.

## CONCLUSIONS

This paper demonstrates that conservative care of stable thoracolumbar fractures yields safe neurological outcomes yet may leave patients with clinically significant disability. Patient-reported outcomes did not associate with commonly reported radiographic measures including kyphosis, global alignment, and spino-pelvic parameters.

## REFERENCES

1. Joaquim AF, Ghizoni E, Tedeschi H, et al. Clinical results of patients with thoracolumbar spine trauma treated according to the Thoracolumbar Injury Classification and Severity Score. *J Neurosurg Spine*. 2014;20(5):562–567.
2. Vaccaro AR, Oner C, Kepler CK, et al. AOSpine thoracolumbar spine injury classification system: fracture description, neurological status, and key modifiers. *Spine (Phila Pa 1976)*. 2013;38(23):2028–2037.
3. Vaccaro AR, Lehman RA Jr, Hurlbert RJ, et al. A new classification of thoracolumbar injuries: the importance of injury morphology, the integrity of the posterior ligamentous

complex, and neurologic status. *Spine (Phila Pa 1976)*. 2005;30(20):2325–2333.

4. Yacoub AR, Joaquim AF, Ghizoni E, et al. Evaluation of the safety and reliability of the newly-proposed AO spine injury classification system. *J Spinal Cord Med*. 2017;40(1):70–75.

5. Schroeder GD, Kepler CK, Koerner JD, et al. Is there a regional difference in morphology interpretation of A3 and A4 fractures among different cultures? *J Neurosurg Spine*. 2016;24(2):332–339.

6. Fairbank JC, Pynsent PB. The Oswestry Disability Index. *Spine (Phila Pa 1976)*. 2000;25(22):2940–2952; discussion 52.

7. Vigatto R, Alexandre NM, Correa Filho HR. Development of a Brazilian Portuguese version of the Oswestry Disability Index: cross-cultural adaptation, reliability, and validity. *Spine (Phila Pa 1976)*. 2007;32(4):481–486.

8. Ware JE Jr. SF-36 health survey update. *Spine (Phila Pa 1976)*. 2000;25(24):3130–3139.

9. Reinhold M, Knop C, Beisse R, et al. Operative treatment of 733 patients with acute thoracolumbar spinal injuries: comprehensive results from the second, prospective, Internet-based multicenter study of the Spine Study Group of the German Association of Trauma Surgery. *Eur Spine J*. 2010;19(10):1657–1676.

10. Joaquim AF, Lawrence B, Daubs M, et al. Measuring the impact of the Thoracolumbar Injury Classification and Severity Score among 458 consecutively treated patients. *J Spinal Cord Med*. 2014;37(1):101–106.

11. Joaquim AF, Fernandes YB, Cavalcante RA, et al. Evaluation of the thoracolumbar injury classification system in thoracic and lumbar spinal trauma. *Spine (Phila Pa 1976)*. 2011;36(1):33–36.

12. Katsuura Y, Osborn JM, Cason GW. The epidemiology of thoracolumbar trauma: a meta-analysis. *J Orthopaedics*. 2016;13(4):383–388.

13. Pneumatics SG, Triantafyllopoulos GK, Giannoudis PV. Advances made in the treatment of thoracolumbar fractures: current trends and future directions. *Injury*. 2013;44(6):703–712.

14. Weninger P, Schultz A, Hertz H. Conservative management of thoracolumbar and lumbar spine compression and burst fractures: functional and radiographic outcomes in 136

cases treated by closed reduction and casting. *Arch Orthopaedic Trauma Surg*. 2009;129(2):207–219.

15. Tezer M, Erturer RE, Ozturk C, et al. Conservative treatment of fractures of the thoracolumbar spine. *Int Orthopaedics*. 2005;29(2):78–82.

16. Bouaicha S, Lamanna C, Jentsch T, et al. Comparison of the sagittal spine lordosis by supine computed tomography and upright conventional radiographs in patients with spinal trauma. *BioMed Res Int*. 2014;2014:967178.

17. Glassman SD, Bridwell K, Dimar JR, et al. The impact of positive sagittal balance in adult spinal deformity. *Spine (Phila Pa 1976)*. 2005;30(18):2024–2029.

18. Keynan O, Fisher CG, Vaccaro A, et al. Radiographic measurement parameters in thoracolumbar fractures: a systematic review and consensus statement of the spine trauma study group. *Spine (Phila Pa 1976)*. 2006;31(5):E156–E165.

**Disclosures and COI:** This paper was supported by FAPESP – Fundação de Amparo a Pesquisa de São Paulo – process 2015/09848-8. No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subject of this manuscript. The authors have no financial interest in the subject of this article. The manuscript submitted does not contain information about medical device(s).

**Corresponding Author:** Andrei F. Joaquim, MD, PhD, Neurosurgery Division, Department of Neurology, University of Campinas, Campinas-SP, Brazil 13083-888. Phone: +55 19 35217372; Email: andjoaquim@yahoo.com.

Published 0 Month 2018

This manuscript is generously published free of charge by ISASS, the International Society for the Advancement of Spine Surgery. Copyright © 2018 ISASS. To see more or order reprints or permissions, see <http://ijssurgery.com>.