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Research Article

Traumatic Lateral Spondyloptosis of the Lumbar Spine: A Case Series and Comprehensive Literature Review

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Introduction

Lateral spondyloptosis of the lumbar spine is a rare and devastating form of traumatic spinal injury. Given the paucity of lumbar lateral spondyloptosis case reports in the literature, the authors seek to inform readers of the clinical, radiological, and operative considerations for three patients with this uncommon clinical presentation, as well as provide a comprehensive review of the literature on this topic.

Methods

A retrospective chart review of three patients admitted to Regional One Health Elvis Presley Memorial Trauma Center in Memphis, TN, with traumatic lateral spondyloptosis of the lumbar spine over a three-year period was performed. We also conducted a comprehensive review of the literature on traumatic lateral lumbar spondyloptosis.

Results

Three cases of traumatic lateral lumbar spondyloptosis were identified. Clinical presentation, radiographic findings, and operative considerations are presented.

Conclusions

Traumatic lateral lumbar spondyloptosis is a rare form of translation injury associated with severe neurological deficits. Our experience and thorough literature review broadly advocate for early surgical intervention in these patients. Regardless of whether a neurologic exam is presented, this management strategy may improve neurologic motor outcomes.

Keywords: *lateral lumbar spondyloptosis, lumbar spine trauma, trauma, traumatic spinal injury*

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Knowledge E
enriching | engaging | empowering

1. Introduction

Traumatic spinal injury is a significant health burden in the United States. Specifically, as measured by disability-adjusted life years, the toll of injury has accounted for over 1 million years of healthy life lost over a 44-year span (1,2). Among the most devastating forms of traumatic spinal injury is spondyloptosis. It is described as the complete fracture-dislocation and subluxation (>100%) of adjacent vertebral bodies and often occurs due to high-velocity trauma (3). At the level of injury, the cranial vertebral body demonstrates displacement in the anterior or posterior direction from caudal bony structures in a distraction injury. Less commonly, the injury occurs due to lateral translation, which results in the cranial and caudal vertebrae being forced into a side-by-side position (4–23). In the largest case series reported, spondyloptosis was observed most commonly at the thoracolumbar junction (T10 to L2) or the thoracic spine (T1 to T9)(15). Moreover, a complete neurologic deficit below the level of injury occurred in a significant proportion of spondyloptosis cases (80%), illuminating the unique challenges associated with caring for this patient population (24–26). Given the paucity of lateral lumbar spondyloptosis cases reported in the literature, we describe the clinical, radiological, and operative considerations for three patients with this rare clinical manifestation and provide a current review of the literature.

2. Methods

We performed a retrospective review of patients admitted to Regional One Health Elvis Presley Memorial Trauma Center in Memphis, TN, with traumatic lateral spondyloptosis of the lumbar spine between 2019 and 2022 and identified 3 patients. Clinical, radiological, and operative reports were reviewed for all patients. Our institution waived informed consent through IRB permissions from our institution.

For the literature review of reported cases of lateral lumbar spondyloptosis, PubMed and Google Scholar were searched from database inception to October 1st 2022, using the combination of Boolean operators "OR" and "AND" and search terms: "lumbar", "lateral", "spondyloptosis", "spondy*", and "dislocation". The resulting publications were carefully reviewed to exclude reports of anterior or posterior spondyloptosis, non-lumbar spondyloptosis, and traumatic spondylolisthesis.

3. Results

3.1. Case 1

The patient was a 34-year-old male who presented after a motor vehicle accident. On initial evaluation, the patient endorsed back pain and numbness of the left lower extremity. The motor exam showed 4+/5 plantar flexion weakness bilaterally 4+/5 weakness of left knee extension, and decreased sensation throughout the left lower extremity. Imaging revealed L3-L4 lateral spondyloptosis, as well as rib fractures and retroperitoneal hematoma (Figure 1, A-D).

The patient underwent an open reduction of L3-L4 fracture with L1-S1 posterior instrumentation, fixation, and fusion within 48 hours of presentation. The right L3 and left L4 pedicles were fractured off their respective vertebral bodies, but fixed-angle screws were placed unilaterally. Polyaxial screws were placed at all other levels. Successful reduction was achieved with the introduction of temporary rods and sequential distraction and de-rotation across L3-L4. Intraoperative nerve monitoring indicated slightly diminished left lower extremity motors after positioning but remained stable throughout the operation.

The patient's postoperative course was uncomplicated, and he was discharged from the hospital with a similar exam to the presentation. At five-month follow-up, the patient demonstrated full motor strength throughout with stable imaging (Figure 1, E-F).

3.2. Case 2

The patient was a 34-year-old female who presented with multiple traumatic injuries after being struck by a motor vehicle. She was intubated on arrival with bilateral chest tube placement. In addition to numerous abdominal injuries, bilateral pneumothoraces, and multiple rib fractures, the patient was found to have L3-4 lateral spondyloptosis (Figure 2, A-D). She was able to open her eyes to voice and follow commands in bilateral upper extremities. She was unable to move her lower extremities bilaterally even with painful stimulation and denied sensation in her lower extremities, and as such, was deemed to have a complete neurological injury.

Due to multiple abdominal and vascular injuries, neurosurgical intervention was delayed until ten days after presentation when the patient was hemodynamically stable. She underwent an open reduction of the L3-L4 fracture with L1-S1 posterior instrumentation and fusion. The initial reduction was achieved under fluoroscopic guidance using traction from spinous process clamps at L2 and L5, as well as manual traction applied to the patient's shoulders and legs. There was a complex dural tear with nerve root disruption. Bilateral sagittal adjusting (SAS) screws were placed at L1-L4 and S1. Bilateral polyaxial screws were introduced at L5 as SAS screws were too lateral to accommodate for rod placement at this level. The deformity was further corrected with bilateral rod placement. (Figure 2, E-F). A muscle flap was used to repair the dural defect.

The patient's postoperative hospital course was prolonged but uncomplicated. Neurologic exam on discharge and one month after initial presentation remained unchanged with the absence of motor and sensory function of bilateral lower extremities. The patient was unfortunately lost to follow up since discharge.

3.3. Case 3

Patient was a 26-year-old male who presented with multiple traumatic injuries after a 6-foot fall at work, landing on his lateral abdomen on a railing. He was intubated on arrival and underwent an emergent exploratory laparotomy. Subsequent imaging revealed lateral spondyloptosis at L2-L3 (Figure 3, A-F). On initial neurologic exam, the patient had significant lower extremity weakness, specifically 1/5 hip flexion, 2/5 knee extension, 3/5 dorsiflexion and plantarflexion on the left and 1/5 hip flexion, knee extension, dorsiflexion and 3/5 plantarflexion on the right.

Two days after presentation, the patient underwent an urgent open reduction of the L2-L3 fracture with L2-L3 laminectomy and L3 right facetectomy. Bilateral pedicle screws were placed at L1-L2 and L4-L5. A unilateral left-sided pedicle screw was placed at L3. A reduction was achieved using temporary rods and sequential distraction. A complex dural injury was noted at L2-L3 with an avulsion of the left L3 root. The durotomy was repaired with a muscle flap.

His postoperative hospital course was uncomplicated. Neurologic exam at discharge indicated significant improvement, with 4/5 strength throughout the left lower extremity except for 4-/5 dorsiflexion and 2/5 hip flexion, 3/5 knee extension, 4/5 dorsiflexion and plantarflexion on the right. He had paresthesias in bilateral lower extremities but otherwise intact sensation. The patient continued to follow up closely in our clinic and eventually required the placement of a dorsal column stimulator due to persistent back and left leg pain. At a three-year follow-up, postoperative imaging demonstrated stable spinal instrumentation (Figure 3, G-H), and the patient was fully ambulatory with some residual left lower extremity weakness.

Table I. Patient Demographics and Presenting Injury.

Number of patients	*26*	
Mean Age (years)	32.8	
Pediatric Patients (<18)		4
Sex	*Male*	18
	Female	8
Mechanism of Injury	*MVC*	13
	Fall	9
	Crush	1
	–	3
Level of Injury	*T12-L1*	5
	L1-2	8
	L2-3	6
	L3-4	5
	L4-5	0
	L5-S1	2
ASIA Score at Presentation	*A*	17
	B	2
	C	3
	D	4
	E	0
	No	9
	–	3

–, not reported or non-applicable.

Table II. Surgical Intervention and Follow-up. n=26.

Time to OR since Presentation	*< 48 hours*	*9*
	> 48 hours	8
	–	9
Surgery	*Posterior Fusion Only*	21
	Posterior + Anterior	1
	Posterior + Lateral	1
	No surgery	2
Neuromonitoring	*Yes*	2
	No	2
	–	22
Dural Tear	*Yes*	7
	No	14
	–	5
Neurologic Improvement at Follow-up	*Yes*	14
	No	9
	–	3

–, not reported or non-applicable.

Table III. Reported Cases of Traumatic Lateral Lumbar Spondyloptosis.

Author, Year	Number of Patients	Age (Years)	Sex	Mechanism of Injury	Injury Level	Presenting Neurologic Status	PIF (level(s), procedure)	Dural Defect (Y/N, repair)	Time to Surgery	Neurologic Improvement at Follow-up
Guttman, 1976[4]	1	–	F	–	L1-L2	ASIA A	Unspecified, no reduction	N	6w	Y
Hellner et al., 1970[5]	1	56	F	–	L2-L3	ASIA D	No surgery	N	NA	NA
Suomalainen & Paakkonen, 1984[6]	1	17	M	MVA	L3-L4	ASIA B	Unspecified	Y, sutured	<1d	Y
Bellew & Bartholomew, 2007[7]	1	36	F	MVA	L2-L3	ASIA A	T11-S1, PSRF	N	3w	Y
Yadla et al., 2008[8]	1	21	M	MVA	L1-L2	ASIA C	T10-L4, PSRF	N	NR	Y
Cherian & Dhawan, 2009[9]	1	4	F	FFH	L1-L2	ASIA A	Unspecified, laminar hooks + rods	N	NR	Y
Martin et al., 2009[10]	1	37	M	FFH	L2-L3	ASIA D	T12-S1	N	5d	Y
Wilkinson et al., 2011[11]	1	16	F	MVA	L3-L4	ASIA B	L1-Ilium	N	1d	Y
Chandrashekhara et al., 2011[12]	1	16	M	MVA	L3-L4	ASIA A	L1-L2 + L4-L5, PSRF	N	NR	N
Yadav & Sharma, 2013[13]	1	45	M	FFH	T12-L1	ASIA A	T10-L2, PSRF	N	6d	N
Arandi 2015[14]	1	22	M	MVA	L5-S1	ASIA C	L3-L5 + Ilium	–	2d	Y
Mishra et al., 2015[15]	1	18	M	FFH	L1-L2	ASIA A	T12-L4	–	NR	N
Garg et al., 2018[16]	2	18	M	MVA	L1-L2	ASIA A	T12-L1 + L4, PSRF; T12-L4 rods	N	7d	N
		50	M	MVA	T12-L1	ASIA A	T10-T12 + L2-L3, PSRF	N	NR	N
Koruga et al., 2020[17]	1	48	M	MVA	L1-L2	ASIA D	T12-L4	N	NR	Y
Jindong & Qing, 2020[18]	1	56	M	FFH	L2-L3	ASIA A	T12-L4	Y, –	<1d	Y
Singh et al., 2021[19]	3	48	M	FFH	T12-L1	ASIA A	T10-L3	Y, –	<1d	N
		33	M	FFH	L1-L2	ASIA A	T11-L4	Y, –	<1d	N
		55	M	FFH	T12-L1	ASIA A	No surgery	–	NA	NR
Barwar 2021[20]	1	24	F	MVA	L5-S1	ASIA A	L3-L5	N	1d	Y
Nekhlopochyn et al., 2021[21]	1	21	M	MVA	T12-L1	ASIA A	T10-11 + L2-L3, PSRF	–	12w	NR
Cheng et al., 2022[22]	1	47	F	Crush	L2-L3	ASIA A	L1-L2 + L4-L5, PSRF	Y, sutured	NR	Y
Wang et al., 2013[23]	1	37	M	–	L1-L2	ASIA A	T11-L3	N	3w	N
Current Study, 2022	3	34	M	MVA	L3-L4	ASIA D	L1-L2 + L5-S1, PSRF; L3, SAS; Right L1-L3 + Left L4-S1, rods	N	2d	Y
		26	M	FFH	L2-L3	ASIA C	L1-L5	Y, muscle flap	2d	Y
		34	F	MVA	L3-L4	ASIA A	L1-L4 + S1, SAS; L5, MAS; L1-S1 rods	Y, muscle flap	10d	N

MVA, motor vehicle accident; FFH, fall from height; –, not reported; PIF, posterior instrumentation and fusion; PSRF, pedicle screw-rod fixation; SAS, sagittal adjusting screw; d, days; w, weeks

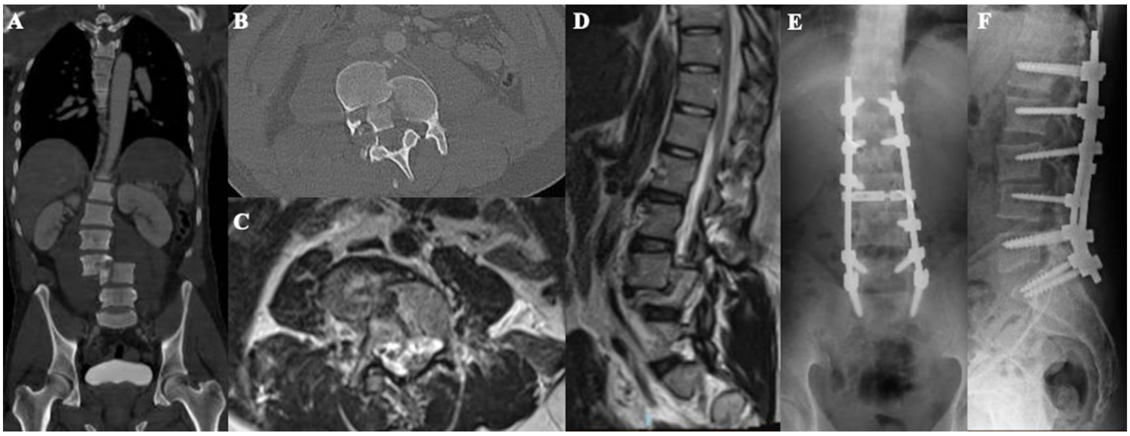

Figure 1. Patient 1: Pre-operative and post-operative imaging of L3-L4 lateral spondyloptosis and subsequent reduction and fusion. A) Coronal CT; B) Sagittal CT; C) Axial MRI; D) Sagittal MRI; E, F) Coronal and Sagittal post-operative XRs at latest follow-up.

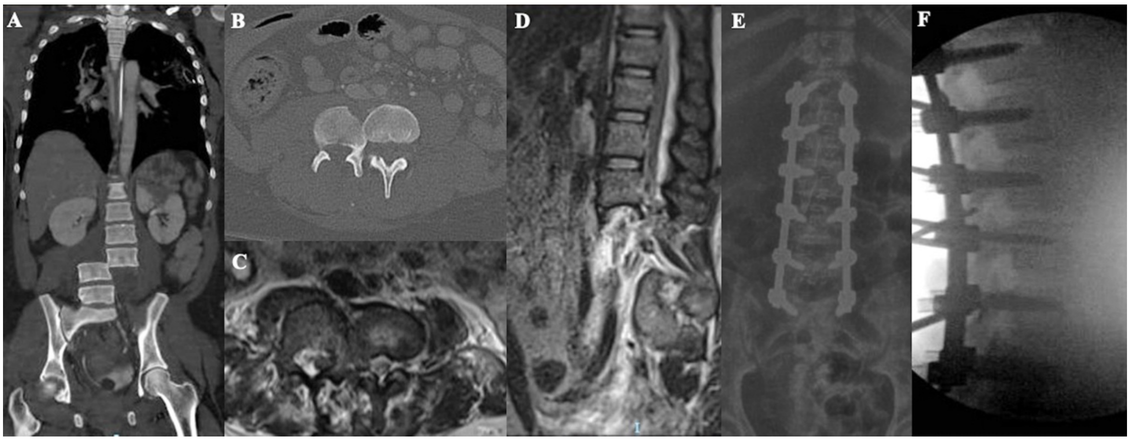

Figure 2. Patient 2: Pre-operative and post-operative imaging revealing L3-L4 lateral spondyloptosis and subsequent reduction and fusion. A) Coronal CT; B) Sagittal CT; C) Axial MRI; D) Sagittal MRI; E, F) Coronal and Sagittal intra-operative XRs.

Figure 3. Patient 3: Pre-operative and post-operative imaging revealing L2-L3 lateral spondyloptosis and subsequent reduction and fusion. A, B) Coronal 3D reconstructions of CT; C, D) Sagittal MRIs; E) Axial CT; F) Axial MRI; G, H) Coronal and Sagittal post-operative XRs at latest follow-up.

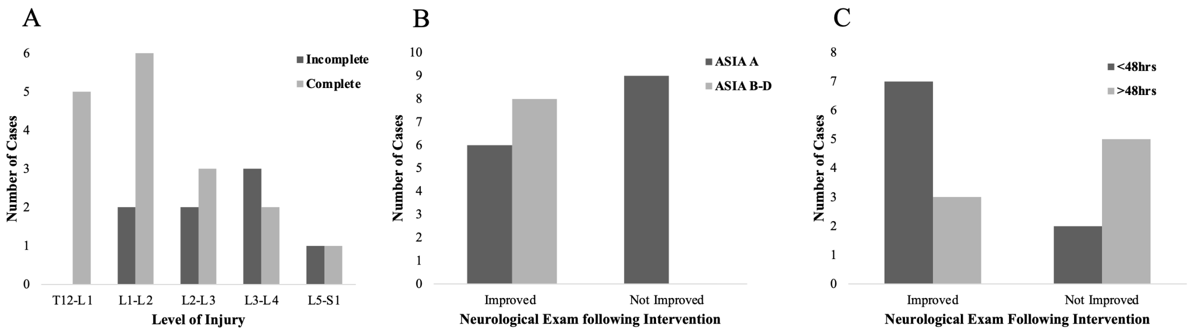

Figure 4. A) Number of cases presenting with complete and incomplete spinal cord injuries based on level of injury; B) Number of cases with improved versus not improved neurologic status following surgical intervention based on ASIA score at presentation. C) Number of cases with improved versus not improved neurologic status following surgical intervention within <48h or >48h from initial presenting injury.

4. Discussion

Traumatic spondyloptosis of the lumbar spine is a rare but severe injury. While anterior or posterior complete dislocation is more common, lateral translation can also occur. Few cases of lateral spondyloptosis have been reported in the literature, with the majority involving the thoracic or lumbar spine. A detailed review of the literature on traumatic lateral spondyloptosis of the lumbar spine yielded results from 20 peer-reviewed publications with a total of 23 patients. Patient demographics and patient-specific management are reported in Tables 1 and 2, respectively. Including the patients from the current study, there are 26 patients with traumatic lateral lumbar spondyloptosis described in the literature (Table 3). To summarize our findings, the majority of patients were male (69%), with a mean age of 32.8 years. While most patients were young adults, there were four reported pediatric cases, with the youngest being 4 years of age. The majority of the patients were presented after motor vehicle accidents (57%), with an ASIA score of A (65%). Broadly, injuries were localized to T12-L4. More specifically, L1-L2 (31%) was the most common level of injury, with two injuries at L5-S1 and none at L4-L5.

The exact mechanism of injury leading to lateral spondyloptotic dislocation is not well described, but previously described cases of lateral optosis have been attributed to shearing and axial compression (12,18). Specifically, fractures and ligamentous rupture due to either a shearing or flexion-rotation force result in traumatic spinal disarticulation (12). Such forces can be generated through high-energy traumatic impacts, including motor vehicle or motorcycle crashes, falls from great heights, or crushing injuries. The multi-system injuries and high mortality rates following these traumatic events may account for the paucity of spondyloptosis described in the literature (27). Of all fracture types, these injuries have the highest association with spinal cord injury and thus, spinal cord injury is common in spondyloptotic patients (26). In a study including 20 patients with traumatic spondyloptosis of the thoracolumbar spine, the spinal cord was deformed and transected in 40% and 35% of the patients, respectively (15). Of the 26 patients included in our literature review, 33% were found to have a dural tear and 35% presented with incomplete neurologic injuries. Optotic fractures of the lumbar spine likely confer less risk of complete spinal cord injury, given the advantageous anatomic relationship beneath the conus. In fact, 57% of patients with injuries between L3-S1 presented with incomplete spinal cord injuries as compared to only 22% of patients with injuries between T12-L3 (Figure 4, A). Additionally, it is likely that dural tears, which in these injuries were often large tears, may allow for decompression of the spinal cord and rootlets due to subsequent release of cerebrospinal fluid and thus prevent a more severe spinal cord injury in certain cases.

Surgical repair of spondyloptotic fractures was indicated to correct spinal alignment, prevent the development of progressive deformity, and, if possible, restore neurologic function. The latter is important, especially when considering the timing of surgery. In cases with a reported post-operative exam, 61% of the patients showed improved neurological function. Improvement in post-operative neurologic exam was reported in all patients who presented as ASIA B-D and only in 40% of patients who presented as ASIA A (Figure 4, B). These findings highlight the value of offering surgical treatment to these patients, regardless of the severity of spinal cord and/or nerve root injury.

The timing of surgery should also be carefully addressed. Several studies have investigated the timing of surgery following traumatic thoracolumbar spine injuries and suggest that early decompression and stabilization of these patients is preferred as it may impact neurological outcomes, hospital-related complications, length of stay, and even length of rehabilitation (28,29). Among the patients included in our review with reported time to operative intervention, only 53% underwent surgery within 48 hours from presentation. One patient was reportedly operated on three months after the presentation (21). The most commonly reported explanation for delayed surgical intervention was instability due to multi-system traumatic injuries. Likewise, surgery was delayed until day 10 for one patient in our case series due to hemodynamic instability from multiple abdominal and thoracic injuries (Case 2). Seventy-eight percent of patients who underwent early surgical intervention showed neurological improvement versus only 38% of patients with delayed surgery (Figure 4, C). However, 88% of patients with delayed intervention presented as ASIA A, and of those patients, only 25% reported neurologic improvement post-operatively. Interestingly, two of the four ASIA A patients who underwent early surgical intervention showed neurological improvement. These findings indicate that early intervention should be considered in these patients as it may influence neurological recovery.

The main surgical challenge with spondyloptotic fractures, especially lateral spondyloptosis, is the successful reduction and adequate stabilization of the spine without causing further neurological injury. While the Magerl classification recognized the lateral slip as a distinct subtype (C2), the newer AO classification groups all translational injuries into one category (C). Accordingly, the goal of management may be universal for fracture-dislocation injuries, but nonetheless, various techniques remain supported by the literature. Such management strategies include stepwise reduction with temporary rods, use of manual traction intra-operatively, vertebrectomies, as well as screw placement techniques (30,31). Vertebrectomies or corpectomies should be considered for significant comminuted fractures of the vertebral bodies, and at times, it could be necessary to perform in order to allow for proper reduction of the spondyloptosis. Screw placement techniques are also important to consider, and proper utilization of fixed and polyaxial screws allows for adequate rod placement without excessive rod bending. A recent study reported a stepwise reduction using a sandbag that was deflated and re-inflated throughout the procedure to assist in the reduction (32). Immediate reduction with positioning alone has also been reported but would be difficult to achieve in patients with lateral spondyloptosis (20,33). The use of pre-operative bedside traction methods, including halo-pelvic tractions and cranio-bifemoral tractions, has also been described. Interestingly, the use of intra-operative monitoring was reported in only two out of the 26 cases, including one case in our series for a patient who had an incomplete neurologic injury. Some or all of these techniques can be utilized for a reduction in lateral lumbar spondyloptosis. In all of our cases, reduction of the spondyloptosis was achieved through the use of stepwise distraction and reduction with temporary rods combined with intra-operative manual traction. We achieved complete reduction with adequate stabilization of the spine in all cases. However, it is important to note that complete reduction may not be achievable in 20-30% of cases (15,20). In such cases, ensuring adequate spine stabilization is essential. Lastly, awareness of large vessel injury is crucial when operating on patients with lumbar spondyloptosis. We did not encounter significant vascular injuries in our patients nor in our review of the literature. Regardless, as such injuries could be devastating, pre-operative vascular imaging should be considered, especially when higher lumbar spine levels are involved.

5. Conclusion

Traumatic lateral lumbar spondyloptosis is a rare but serious injury. Surgical intervention is important in these patients, not only for spinal stabilization and deformity prevention but also to provide an opportunity for restoring neurological function.

Conflicts of Interest

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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Author Contributions

All authors contributed significantly to the production of the manuscript.

Erin Miller: Writing- Original draft, Visualization; Emal Lesha: Conceptualization, Project Administration, Formal Analysis; Jordan Roach: Writing- Original draft; Garrett Venable: Writing: Review & Editing; William Mangham: Writing-Review & Editing; Mallory Dacus: Investigation; Deke Blum: Investigation; Michael Muhlbauer: Investigation; Raul Cardenas: Supervision.

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