DOI: https://doi.org/10.17650/1683-3295-2024-26-3-135-143

TRAUMATIC LATERAL SPONDYLOPTOSIS AND LATERALOPTOSIS WITH PARTIAL IMPROVEMENT THROUGH POSTERIOR SURGICAL APPROACH: A REVIEW BASED ON A CASE REPORT

G. Vasquez-Paredes[1, 2], C. Zavaleta-Corvera[1], O. Riveros-Hernandez[1, 2], J. Caballero-Alvarado[3], L.S. Muente-Alva[1]

[1]School of Medicine, Antenor Orrego Private University; Trujillo, 13007, Peru;
[2]Neurosurgery Department, Belen Hospital of Trujillo; Trujillo, 13007, Peru;
[3]Surgery Department, Regional Hospital of Trujillo; Trujillo, 13007, Peru

Contacts: Carlos Zavaleta-Corvera *carzavcor_1992@hotmail.com*

Introduction. Spondyloptosis or grade V of spondylolisthesis, spinal injury that involve 100 % mobilization of the vertebral body, is rare to find. Lateraloptosis, displacement of vertebral bodies, is even more rare a catastrophic.
The aim of this study to introduce readers to this rare form of traumatic lumbar spine injury as well as to review current available therapeutic approaches.
Case report. A 22-year-old male was admitted to the emergency room due to a fall from a moving truck. Physical examination revealed neurological deficit in the lower extremities, with muscle strength 0/5, and an ASIA B classification. Computed tomography study showed a complete lateroloptosis at the L_3–L_4 level. The patient is admitted to the operating room for surgical treatment through a posterior approach. Successful arthrodesis and spinal alignment are achieved. Immediate postoperative period, showed no complications and the patient's neurological function in the lower extremities was classified as ASIA C. In the posterior follow-up, the patient maintains the motor neurological function and recover the autonomic control of bladder function. With mild disability according to the Barthel Index of 90 points.
Discussion. of the traumatic spinal injuries, spondyloptosis is the most infrequent and occurs secondary to high-energy mechanisms. It presents an incidence of complete neurological deficit in 80 % of patients. The objectives in surgical treatment are decompression of neurovascular structures, reduction of fracture dislocation to improve alignment in the sagittal and coronal plane, and instrumentation that allows stability. The posterior surgical approach offers advantages over the anterior approach. In the posterior approach, the facet joints can be manipulated more safely, decompress the nerve roots and the dural sac more easily, as well as less operating time and greater care of vascular structures such as the iliac vessels.
Conclusion. Complex traumatic spinal injuries are associated with irreversible neurological damage. Achieving spinal stability and alignment allows optimizing physical therapy and rehabilitation for greater recovery. Severe spinal injuries, especially lateroptosis, are difficult to treat by surgical approach, however, the main objective is vertebral stabilization to allow physical therapy and early rehabilitation.

Keywords: spinal injuries, fracture dislocation, spondylolisthesis, therapeutic approaches, laminectomy (DeC MeSH)

For citation: Vasquez-Paredes G., Zavaleta-Corvera C., Riveros-Hernandez O. et al. Traumatic lateral spondyloptosis and lateraloptosis with partial improvement through posterior surgical approach: a review based on a case report. Neyrokhirurgiya = Russian Journal of Neurosurgery 2024;26(3):135–43.
DOI: https://doi.org/10.17650/1683-3295-2024-26-3-135-143

Травматический боковой спондилоптоз с частичным улучшением после хирургического лечения через задний доступ: обзор, основанный на клиническом случае

G. Vasquez-Paredes[1, 2], C. Zavaleta-Corvera[1], O. Riveros-Hernandez[1, 2], J. Caballero-Alvarado[3], L.S. Muente-Alva[1]

[1]School of Medicine, Antenor Orrego Private University; Trujillo, 13007, Peru;
[2]Neurosurgery Department, Belen Hospital of Trujillo; Trujillo, 13007, Peru;
[3]Surgery Department, Regional Hospital of Trujillo; Trujillo, 13007, Peru

Контакты: Carlos Zavaleta Corvera *carzavcor_1992@hotmail.com*

Введение. Спондилоптоз, или спондилолистез V степени, – очень редкая травма позвоночника, приводящая к 100 % мобилизации позвонка. Боковой спондилоптоз, представляющий собой полное смещение позвонка, встречается еще реже и имеет более катастрофические последствия.
Цель работы – познакомить читателей с этой редкой формой травмы поясничного отдела позвоночника и представить обзор современных терапевтических подходов к лечению такой травмы.
Клинический случай. Мужчина, 22 лет, доставлен в отделение скорой помощи после падения с движущегося грузового автомобиля. При обследовании выявлен неврологический дефицит в нижних конечностях с мышечной силой 0/5 и степенью B по классификации Американской ассоциации травм позвоночника (American Spinal Injury Association, ASIA). Компьютерная томография показала полный боковой спондилоптоз на уровне позвонков L_3–L_4. Пациента перевели в операционную для хирургического лечения с применением заднего доступа. Успешно выполнены артродез и коррекция линии позвоночника. В ближайшем постоперационном периоде осложнений не наблюдалось, неврологическая функция нижних конечностей пациента была классифицирована как C по шкале ASIA. В отдаленном периоде у пациента сохраняется двигательная неврологическая функция и восстановился произвольный контроль мочеиспускания. Пациент имеет легкую степень инвалидности, индекс Бартела – 90.
Обсуждение. Из всех травм позвоночника спондилоптоз является наиболее редкой и развивается в результате высокоэнергетических воздействий. У 80 % пациентов такая травма приводит к полному неврологическому дефициту. Целями хирургического лечения являются декомпрессия нейрососудистых структур, снижение степени дислокации перелома для восстановления линии позвоночника в сагиттальной и фронтальной плоскостях и установка инструментов, обеспечивающих стабильность. Задний хирургический доступ имеет преимущества по сравнению с передним. При заднем доступе манипуляции с фасеточными суставами безопаснее, проще провести декомпрессию нервных корешков и оболочек спинного мозга, время операции короче и больше внимания уделяется таким сосудистым структурам, как подвздошные сосуды.
Заключение. Сложные травмы позвоночника связаны с необратимыми неврологическими повреждениями. Достижение стабильности и правильной линии позвоночника позволяет оптимизировать физическую терапию и реабилитацию для лучшего восстановления пациента. Тяжелые травмы позвоночника, особенно боковой спондилоптоз, сложны для хирургического лечения, однако основной целью стабилизации позвоночника является возможность физической терапии и ранней реабилитации.

Ключевые слова: травма позвоночника, переломовывих, спондилолистез, терапевтический подход, ламинэктомия (DeC MeSH)

Для цитирования: Vasquez-Paredes G., Zavaleta-Corvera C., Riveros-Hernandez O. et al. Traumatic lateral spondyloptosis and lateraloptosis with partial improvement through posterior surgical approach: a review based on a case report. Нейрохирургия 2024;26(3):135–43. (На англ.).
DOI: https://doi.org/10.17650/1683-3295-2024-26-3-135-143

INTRODUCTION

Severe mobilization, subluxation, or dislocation of the spinal vertebrae is called traumatic lumbar spondylolisthesis. These types of injuries, mostly traumatic and secondary to high-energy impacts, rarely involve 100 percent displacement of the vertebral body in the coronal or sagittal plane. When the displacement occurs in more than 100 % of the contact it is called spondyloptosis. Whereas, when the contiguous vertebral bodies are next to each other in coronal view, it is called lateraloptosis. Although both events rarely occur in the same patient, when they do occur, they often greatly increase morbidity and mortality rates in patients [1, 2].

Within the evaluation of the displacement of this type of lesions, the Meyerding classification is used. Such Score classifies and subdivides vertebral lesions according to their displacement percentage in relation to the caudal vertebra in five degrees. Grade I presents a translation of up to 25 %, grade II between 25 and 50 %, grade III between 50 and 75 %, grade IV between 75 and 100 %, and grade V greater than 100 %. Therefore, according to this classification, spondyloptosis is described as a single grade V spondylolisthesis, which presents through a subluxation or dislocation greater than 100 %. Such injuries are by themselves independent factors of poor prognosis and poor outcomes due to direct injury to the spinal cord and/or spinal nerve roots and loss of spinal alignment [3, 4].

In traumatic spondyloptosis, traffic accidents or falls from great heights are the most important causal factors as high energy generators. The post-trauma patient will develop symptoms such as neurological deficits, mainly of the motor type with paraplegia in almost 80 to 90 % of the patients involved. In addition, autonomic loss associated with the damage that mainly involves urination and evacuation of feces may also occur the lower the lesion occurs [5].

Thus, the absolute and complete instability of the spinal structure can have serious repercussions if it is not treated properly and on time. Conservative treatment has proven to be ineffective, with spinal surgery being the only recovery option. The primary goal of surgical treatment is surgical decompression and reduction to align and stabilize the spine. We describe a challenging case of lateraloptosis surgically approached through a posterior approach. However, due to the complexity of the structures and the surgical intervention itself, surgical treatment remains a challenge [4, 6].

CASE REPORT

A 22-year-old man was admitted to the emergency department for falling from a moving truck, which lost its way and fell into a ravine of approximately 30 meters. On admission, he reported pain in the lumbar region, lack of mobility in the lower limbs 0/5 according to the MRC (Medical Research Council) modified muscle strength scale, preservation of sensory function below L_4, osteotendinous areflexia of the lower limbs and absence of anal tone. It was classified as ASIA B. For this reason, a non-contrast lumbar computed tomography was performed, showing evidence of a fracture dislocation at the L_4: C: N_3: M_1 level according to the AOSpine and Thoracolumbar Injury Classification Substem (TLICS) 9 points and Classification of Wiltse IV, associated with fracture of the posterior elements of the spine and spondylolisthesis of L_3–L_4 (Fig. 1, 2).

For this reason, it was decided to admit the patient to the operating room for surgical intervention through a posterior approach. A multidisciplinary team of neurosurgeons, anesthesiologist, medical technologist, scrub nurse, nursing technician enters the operating room.

Procedure description. *The patient was placed in the prone position with pads on the chin, shoulders, pelvis, knees, and elevated feet. First, a total L_4 corpectomy was performed, with release of fibrous tissue adjacent to the compromised bone structures. A complete dural lesion was evidenced, with exposure of nerve roots and leakage of cerebrospinal fluid, for which a duroplasty was performed using a dura mater substitute and sutured with 5/0 nylon. In addition, posterior lumbar instrumentation was performed with 8 transpedicular screws above and below the fractured vertebra, followed by reduction of the spondylolisthesis.*

Thus, pedicle screws were inserted in vertebrae L_1, L_2, L_3 and L_5 towards the vertebral bodies with radiological guidance and two rods were placed in the pedicle heads with locking head nuts in order to stabilize the spine. In addition, a crossbar was placed (crosslink) to give greater stability. Through the procedure, complete reduction of spondylolisthesis was achieved (Fig. 3, 4).

The patient had no postoperative complications, received physical therapy and rehabilitation, showing a partial improvement in the strength of the lower limbs 3/5, classified as ASIA C and bladder control without the need to use a bladder catheter at 3 months (Fig. 5). With mild disability according to the Barthel Index of 90 points.

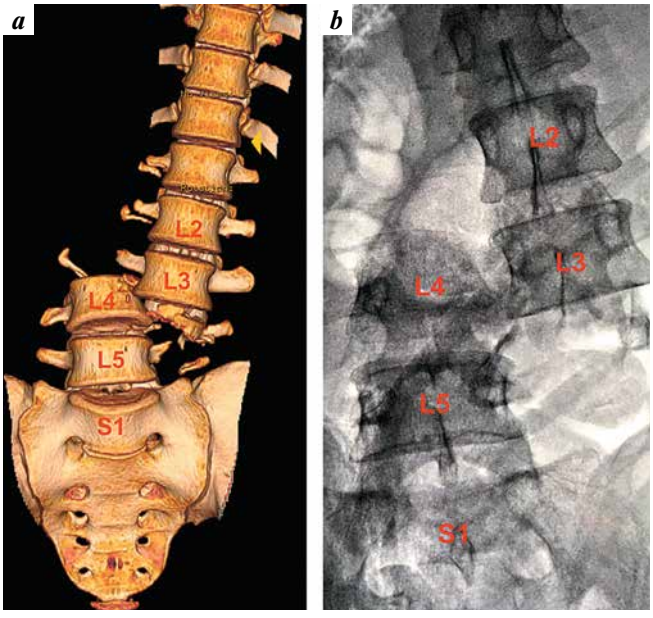

Fig. 1. *(Computed tomography with 3D reconstruction showing L_3–L_4 dislocation (a). (Lumbar anteroposterior X-ray showing the L_3–L_4 dislocation (b)*

DISCUSSION

Based on the information collected, a search was made in databases such as PubMed, ScienceDirect and Elsevier

Fig. 2. *Lumbar computed tomography showing L_3–L_4 dislocation (a). Lumbar computed tomography showing the L_3–L_4 dislocation (b)*

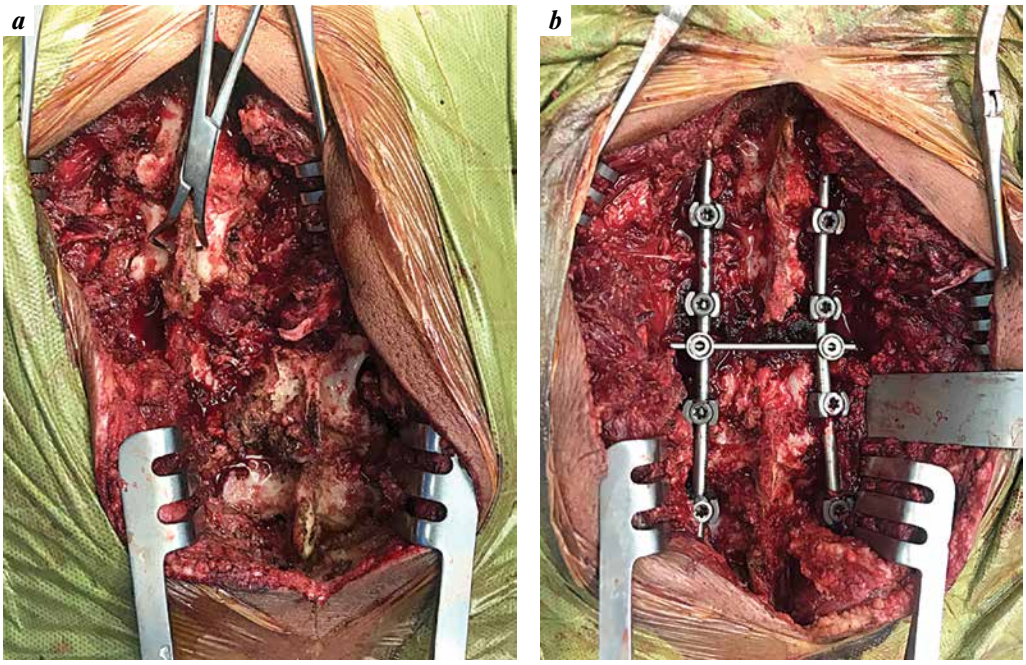

Fig. 3. *Intraoperative photograph showing the L_3–L_4 dislocation (a). Intraoperative photograph showing spinal alignment with the placement of 8 transpedicular screws and 2 lateral bars in addition to an intermediate bar (crosslink) (b)*

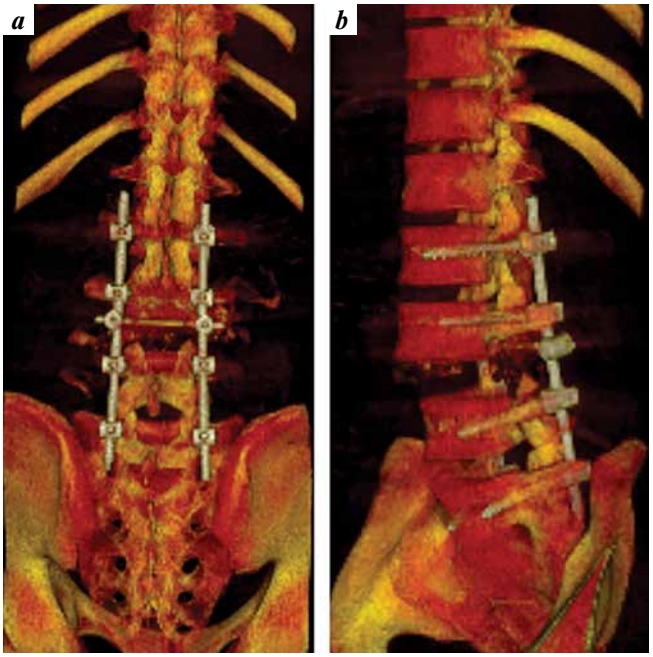

Fig. 4. *Postoperative tomography of the lumbar spine with 3D reconstruction in anteroposterior view showing correct vertebral alignment (a). Postoperative tomography of the lumbar spine with 3D reconstruction in lateral view showing almost complete reduction of spondylolisthesis (b)*

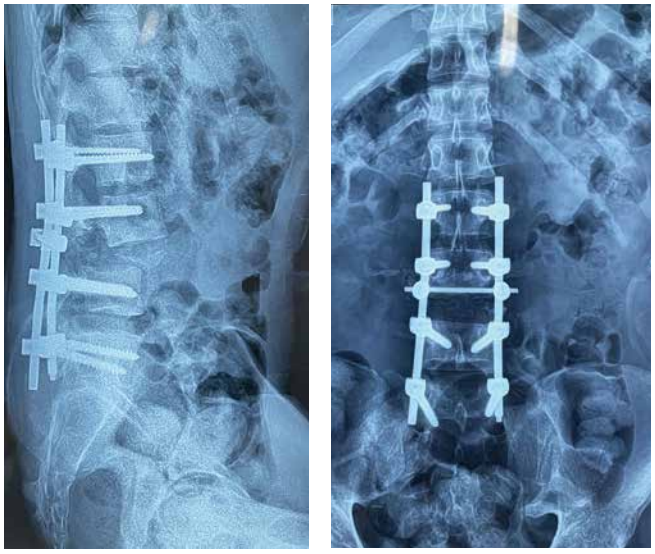

Fig. 5. *Radiographic control 3 months postoperatively demonstrating successful spinal arthrodesis and alignment and the integrity of the instrumentation*

using the advanced search strategy (("spondyloptosis") OR ("lateraloptosis")) OR ("spine trauma"), modified for each database in order to carry out a review of the available information about the surgical approach and the management of spondyloptosis-type spinal lesions. The selection of articles included those with the characteristics of a case report or series of cases published after 2018 to date.

The available information shows that most cases occur in young adult patients, being much rarer in pediatric patients or older adult patients (Table 1). The gender especially affected is mostly male patients above 90 % of cases. The most important mechanism of injury corresponds to high-impact or high-energy trauma secondary to, in descending order of frequency, automobile accidents, falls from a height, and trauma with large or blunt objects. The most frequent lesion location reported was the thoracolumbar junction, followed by the lumbar area and later the cervical area.

Table 1. *Case reports of lateraloptosis according to clinical characteristics and therapeutic approach*

Author, year	Country	Type of study	Sample	Age, years	Gender	Mechanism of injury	Level affected	Neurologic status	Type of treatment	Treatment results
J. Rocha-Maguey et al., 2023 [8]	México	Case Report	1	34	M	RTA	C_6–C_7	After 3 weeks: urinary retention, progressive instability to walk, constant falls at home, neck deformity with limited mobility, proprioceptive disorders	Double cervical approach, anterior extraction of the C_6–C_7 and C_7–T_1 discs and C_7 corpectomy. Tricortical iliac crest bone graft between C_6 and T_1	Neurological improvement
R. Singh et al., 2022 [9]	India	Cases Series	17	Mean 34.5	M ($n = 12$) F ($n = 5$)	Height fall ($n = 10$) Trauma with object ($n = 4$) RTA ($n = 3$)	C_6–C_7 ($n = 1$) C_7–T_1 ($n = 1$) T_5–T_6 ($n = 1$) T_{12}–L_1 ($n = 7$) T_8–T_9 ($n = 1$) T_{11}–T_{12} ($n = 2$) L_1–L_2 ($n = 2$) L_4–L_5 ($n = 1$) L_5–S_1 ($n = 1$)	ASIA A ($n = 14$) ASIA B ($n = 1$) ASIA C ($n = 1$) ND ($n = 1$)	Operated for spondyloptosis ($n = 15$) Conservative treatment ($n = 2$)	ASIA A ($n = 12$) Death ($n = 2$) Partial recovered: ambulation or bladder function ($n = 3$)
M. Garg et al., 2022 [10]	India	Cases Series	7	18 ($n = 1$) 10 ($n = 1$) 15 ($n = 1$) 18 ($n = 1$) 18 ($n = 1$) 9 ($n = 1$) 18 ($n = 1$)	M ($n = 6$) F ($n = 1$)	RTA ($n = 2$) Fall ($n = 2$) Trauma with object ($n = 3$)	Lumbar ($n = 2$) Toracolumbar ($n = 1$) Lumbar ($n = 4$)	ASIA A	Corpectomy + MESH Cage + fusion ($n = 2$) Corpectomy + fusion ($n = 2$) Only fusion ($n = 2$) Refusal of surgery ($n = 1$)	ASIA A
L. Cheng et al., 2023 [11]	China	Case Report	1	47	F	Trauma with cylindrical object	L_3–L_4	ASIA A	Fixation of posterior bilateral pedicle screws and the construction of rods in the vertebral bodies of the L_1, L_2, L_4 and L_5 segments in the prone position	The patient presented muscle strength 4/5 in left L_2 and L_3, and 3/5 in left L_5 and S_1, while in the right lower extremity it was 2/5. However, perianal sensation remained diminished accompanied by overflow incontinence and relaxation of anal sphincter tone. Sensitivity at the L_2 level disappeared in the right lower limb

End of table 1

Author, year	Country	Type of study	Sample	Age, years	Gender	Mechanism of injury	Level affected	Neurologic status	Type of treatment	Treatment results
T. Tsujimoto et al., 2020 [14]	China	Cases Series	2	60 75	M M	RTA Fall	C_7–T_1	ASIA B ASIA D	Posterior reduction, C_7 vertebral arch and ligament flavum were resected. Lateral mass screws C_5 associated with C_6 and T_1 pedicle & screws were inserted on the left side of C_7. Spinal fusion surgery of C_5 to T_1 pedicle screw and lateral mass screws. Autologous bone graft	ASIA D ASIA E
Z. Jindong et al, 2020 [12]	China	Case Report	1	56	M	Fall	L_2–L_3	ASIA A	Posterior instrumented fusion of T_{12} to L_4 with L_2 corpectomy and iliac bone placement.	ASIA B
F. Xu et al., 2020 [2]	China	Case Report	1	42	M	Height fall	L_3–L_4	ASIA E	L_3–L_4 fusion, PSF at L_2–L_4 and S_1	Pain relief
J.P. Cabrera et al., 2019 [15]	Chile	Case Report	1	42	M	RTA	L_3–L_4	ND	L_3 vertebrectomy. Installation of an expandable grid between L_2 and L_4, posterior and anterior. The pedicles of L_2 and L_4 are fixed	Partial Neurological Improvement
M. Garg et al., 2018 [13]	India	Cases Series	5	42 (n = 1) 18 (n = 1) 38 (n = 1) 28 (n = 1) 50 (n = 1)	M (n = 5)	RTA (n = 5) Fall (n = 1)	Thoracic (n = 3) Toracolumbar (n = 2)	ASIA A	Single stage posterior spinal stabilization (7 days after admission)	ASIA A
V.N. Yamaki et al., 2018 [16]	China	Case Report	1	4	F	Wall Collapse	L_5–S_1	ASIA D	L_5–S_1 discectomy, L_5–S_1 anterior plate fixation, L_4–L_5 laminectomy, L_2–L_3 PSF, and iliac crest screw fixation	ASIA D

Note. *ASIA – American Spinal Injury Association Score; M – male; F – female; ND – no data; RTA – road traffic accident; PSF – pedicle severe fracture.*

According to the classification by A.R. Vaccaro et al., in the TLICS (Thoracolumbar Injury Classification and Severity Score) system, fracture dislocations are the most unstable, causing greater morbidity and mortality [7]. In the present review, the vast majority of patients with thoracolumbar injuries admitted to the emergency service showing severe neurological compromise with the ASIA scale in stage A after the traumatic event. And, despite the surgical treatment, more than 90 % remained with the admission characteristics and 10 % partially improved. Recovery cases are exceptional [2, 8–16].

Thus, the objectives sought in surgical treatment are decompression of neurovascular structures, reduction of fracture dislocation to improve alignment in the sagittal and coronal plane, and instrumentation that allows stability [17]. Different surgical approaches have been reported for the treatment of spondyloptosis; anterior, posterior and combined anterior-posterior. Most surgeons opt for performing interventions through the posterior plane with spinal realignment and stabilization in order to allow early mobilization and rehabilitation of the patient. It is well accepted that the definitive management of spondyloptosis is through surgical fixation. Surgical options are variable, and among them, a surgeon may consider anterior decompression with discectomy or corpectomy and fusion only, posterior lateral mass or pedicle fusion with or without laminectomy, or a 360° fusion [8].

R. Singh et al. through a review of cases, affirms that there are evident benefits in 4-level posterior fixation (2 levels above and 2 levels below the lesion) with pedicle screws and a bar in traumatic spondyloptosis involving the thoracic and thoracolumbar vertebrae, lumbar and lumbosacral. In patients with traumatic cervical spondyloptosis, anterior cervical discectomy and fusion can achieve spinal alignment. Otherwise, posterior reduction and fixation (posterior lateral mass fusion with or without laminectomy) is performed, ie 360° fixation. If the vertebral body of the affected vertebra is damaged, a corpectomy with expandable cage fixation may be required. In their study, a posterior approach was used in most cases and a combined posterior and anterior approach was used in cases of traumatic cervical spondyloptosis [9]. Available evidence suggests that the posterior surgical approach offers certain advantages over the anterior approach from the surgeon's point of view. The anterior approach requires more time and care for vascular structures such as the iliac vessels with catastrophic complications. In the posterior approach, the facet joints can be manipulated more safely, decompressing the nerve roots and the dural sac [17, 18].

However, the available information has not shown significant differences in terms of clinical outcomes for patients who underwent anterior-only, posterior-only, and 360° repair with respect to both immediate postoperative ASIA grade and ASIA grade at the end of the follow-up period. In addition, no association has been found between the injury and the time of surgery in neurological recovery, especially in pain relief. It has also been reported that the greater the extent of the lesion, the greater the neurological deficit and the worse the recovery [19]. In this case, surgical management focused on decompression via the posterior approach, in addition to L_4 corpectomy to free neurovascular structures and reduce dislocation for proper alignment and subsequent transpedicular instrumentation with polyaxial titanium screws to provide support and stability to the lumbar spine. in addition to offering a short hospital stay and early physical rehabilitation.

It is important to mention that, as in spondyloptosis, complete lesions; creates more problems in rehabilitation [20]. Causes impairment of independence and physical function, neurogenic bladder and bowel, urinary tract infections, pressure ulcers, orthostatic hypotension, fractures, deep vein thrombosis, spasticity, autonomic, pulmonary, and cardiovascular dysreflexia. and depressive disorders [21].

Rehabilitation involves the patient and his family, a team from the hospital and the rehabilitation center. There are several factors to be addressed; therapy training in mobility, personal care and activities of daily living; prevention and control of deformities and bedsores; bowel and bladder regulation; pain control; control of vasomotor dysfunction; prevention, control and treatment of renal complications; maintenance of good nutrition without obesity or malnutrition [22].

Special considerations for pediatric patients

Most pediatric spinal injuries (except spondyloptosis) can be treated conservatively unlike adults [23]. However, current criteria to take into account for surgical treatment will consider the potential risks of prolonged immobilization, for this reason surgery is indicated solely for the purpose of decompression of neural elements, very unstable lesions with progressive neurological deficit, dislocations not reducible and progressive deformities [10].

The recommendations are a posterior approach only for circumferential decompression and fusion in children [24]. Thoracolumbar instrumentation with pedicle screws for pediatric traumatic spinal fractures [25]. Try to avoid long segment fixations as much as possible generally because of the potential risk of overgrowth involvement of the pediatric spine [24]. Furthermore, any attempt at reduction and/or alignment of the vertebral bodies may unnecessarily risk injury to nearby vital structures and should be avoided [26].

CONCLUSION

Complex traumatic injuries to the lumbar spine at the L_4 level are very rare injuries that are associated with irreversible neurological damage in most cases. They are unstable dislocations and require surgery to reduce the fracture and achieve stability and alignment of the lumbar

spine, which allows optimizing physical therapy and rehabilitation for greater recovery. The choice of surgical approach varies according to each case and we believe that through a posterior approach we achieve the objectives while minimizing the imminent risks through an anterior approach.

REFERENCES / ЛИТЕРАТУРА

1. Sandquist L., Paris A., Fahim D.K. Definitive single-stage posterior surgical correction of complete traumatic spondyloptosis at the thoracolumbar junction. J Neurosurg Spine 2015;22(6):653–7. DOI: 10.3171/2014.10.SPINE14165
2. Xu F., Tian Z., Fu C. et al. Mid-lumbar traumatic spondyloptosis without neurological deficit: a case report and literature review. Medicine (Baltimore) 2020;99(12):e19578. DOI: 10.1097/MD.0000000000019578
3. Cherian I., Dhawan V. Lateral lumbar spondyloptosis. Int J Emerg Med 2009;2(1):55–6. DOI: 10.1007/s12245-009-0092-0
4. Wilkinson J.S., Riesberry M.A., Mann S.A., Fourney D.R. Traumatic lateral expulsion of the L-4 vertebral body from the spinal column. J Neurosurg Spine 2011;14(4):508–12. DOI: 10.3171/2010.11.SPINE091028
5. Gitelman A., Most M.J., Stephen M. Traumatic thoracic spondyloptosis without neurologic deficit, and treatment with *in situ* fusion. Am J Orthop (Belle Mead NJ) 2009;38(10):162–5.
6. Bellew M.P., Bartholomew B.J. Dramatic neurological recovery with delayed correction of traumatic lumbar spondyloptosis. Case report and review of literature. J Neurosurg Spine 2007;6(6): 606–10. DOI: 10.3171/spi.2007.6.6.16
7. Vaccaro A.R., Zeiller S.C., Hulbert R.J. et al. The thoracolumbar injury severity score: a proposed treatment algorithm. J Spinal Disord Tech 2005;18(3):209–15.
8. Rocha-Maguey J., Martinez-Pablos J. Complete neurological recovery after a chronic C6–C7 spondyloptosis without posterior arch fracture. A new case reported. Interdisciplinary Neurosurgery 2023;32:101733. DOI: 10.1016/j.inat.2023.101733
9. Singh R., Shankar R., Singh A. et al. Traumatic spondyloptosis: neurological, surgical, and outcome perspectives in a tertiary care center. Indian J Neurosurg 2022;11(03):232–40. DOI: 10.1055/s-0041-1726608
10. Garg M., Kumar A., Sawarkar D.P. et al. Management of pediatric and adolescent traumatic thoracolumbar spondyloptosis. Neurol India 2022;70(Suppl):S182–8. DOI: 10.4103/0028-3886.360921
11. Cheng L., Qiu C., Liu X.Y., Sang X.G. Treatment strategy on traumatic mid-lumbar spondyloptosis with concomitant multiple injuries: a case report and literature review. Chin J Traumatol 2023;26(1):33–40. DOI: 10.1016/j.cjtee.2022.06.006
12. Jindong Z., Qing L. Traumatic lateral spondyloptosis of L2 with complete neurological deficit: a case report. Trauma Case Rep 2020;29;100339. DOI: 10.1016/j.tcr.2020.100339
13. Garg M., Kumar A., Sawarkar D.P. et al. Traumatic lateral spondyloptosis: case series. World Neurosurg 2018;113:e166–e71. DOI: 10.1016/j.wneu.2018.01.206
14. Tsujimoto T., Suda K., Matsumoto Harmon S. et al. Two case reports of 'locked spondyloptosis': the most severe traumatic cervical spondyloptosis with locked spinous process and vertebral arch into the spinal canal. Spinal Cord Ser Cases 2020;6(1):10. DOI: 10.1038/s41394-020-0259-8
15. Cabrera J.P., Yankovic W., Luna F. et al. Traumatic spondyloptosis of L3 with incomplete neurological involvement: a case report. Trauma Case Rep 2019;24:100248. DOI: 10.1016/j.tcr.2019.100248
16. Yamaki V.N., Morais B.A., Brock R.S. et al. Traumatic lumbosacral spondyloptosis in a pediatric patient: case report and literature review. Pediatr Neurosurg 2018;53(4):263–9. DOI: 10.1159/000488766
17. Park G.T., Yu D., Kim S.W., Jeon I. Fracture-dislocation of L5 combined with multi-level traumatic spondylolisthesis of the lower lumbar spine treated *via* the posterior-only approach: a case report. Korean J Neurotrauma 2020;16(2):313–9. DOI: 10.13004/kjnt.2020.16.e28
18. Zhou T.H., Tang X., Xu Y.Q., Zhu Y.L. Traumatic spondyloptosis of L4. Spine (Phila Pa 1976) 2010;35(17):E855–9. DOI: 10.1097/BRS.0b013e3181d798f2
19. Wong K.E., Chang P.S., Monasky M.S., Samuelson R.M. Traumatic spondyloptosis of the cervical spine: a case report and discussion of worldwide treatment trends. Surg Neurol Int 2017;8:89. DOI: 10.4103/sni.sni_434_1
20. Lee C.W., Hwang S.C., Im S.B. et al. Traumatic thoracic spondyloptosis: a case report. J Korean Neurosurg Soc 2004;35:622–4.
21. Nas K., Yazmalar L., Şah V. et al. Rehabilitation of spinal cord injuries. World J Orthop 2015;6(1):8–16. DOI: 10.5312/wjo.v6.i1.8
22. Flett P.J. The rehabilitation of children with spinal cord injury. J Paediatr Child Health 1992;28(2):141–6. DOI: 10.1111/j.1440-1754.1992.tb02629.x
23. Grasso G., Paolini S., Sallì M., Torregrossa F. Lumbar spinal fixation removal by a minimal invasive microscope-assisted technique. Case report with technical description. Neurol India 2020;68(5):1211–3. DOI: 10.4103/0028-3886.299148
24. Gressot L.V., Mata J.A., Luerssen T.G., Jea A. Surgical treatment of congenital thoracolumbar spondyloptosis in a 2-year-old child with vertebral column resection and posterior-only circumferential reconstruction of the spine column: case report. J Neurosurg Pediatr 2015;15(2):207–13. DOI: 10.3171/2014.9.PEDS14151
25. Santiago R., Guenther E., Carroll K., Junkins E.P. The clinical presentation of pediatric thoracolumbar fractures. J Trauma 2006;60(1):187–92. DOI: 10.1097/01.ta.0000200852.56822.77
26. Yang S.C., Yu S.W., Chen Y.J., Chen W.J. Surgical treatment for thoracic spine fracture dislocation without neurological deficit. J Formos Med Assoc 2003;102(8):581–5.

Author' contribution
G. Vasquez-Paredes: conception and design, administrative support, provision of study material or patients, collection and assembly of data, data analysis and interpretation, manuscript writing, final approval of manuscript;
C. Zavaleta-Corvera: conception and design, administrative support, collection and assembly of data, data analysis and interpretation, manuscript writing, final approval of manuscript;
O. Riveros-Hernandez: manuscript writing, final approval of manuscript;
J. Caballero-Alvarado: data analysis and interpretation, manuscript writing, final approval of manuscript;
L.S. Muente-Alva: manuscript writing, final approval of manuscript.
Вклад авторов
G. Vasquez-Paredes: концепция и дизайн, административная поддержка, предоставление материалов или данных пациентов, сбор и обобщение данных, анализ и интерпретация данных, написание и окончательное утверждение рукописи;
C. Zavaleta-Corvera: концепция и дизайн, административная поддержка, сбор и обобщение данных, анализ и интерпретация данных, написание и окончательное утверждение рукописи;
O. Riveros-Hernandez: написание и окончательное утверждение рукописи;
J. Caballero-Alvarado: анализ и интерпретация данных, написание и окончательное утверждение рукописи;
L.S. Muente-Alva: написание и окончательное утверждение рукописи.

ORCID of author / ORCID автора
Carlos Zavaleta Corvera: https://orcid.org/0000-0001-5918-8261

Conflict of interest. The authors declare no conflict of interest.
Конфликт интересов. Авторы заявляют об отсутствии конфликта интересов.

Funding. The work was performed without external funding.
Финансирование. Работа выполнена без спонсорской поддержки.

Compliance with patient rights and principles of bioethics. The authors declare that no experiments on humans or animals have been performed in this manuscript. The authors declare that no patient data appears in this article.
Соблюдение прав пациентов и правил биоэтики. Авторы заявляют, что в данной работе не проводилось никаких экспериментов на людях или животных. Авторы заявляют, что в этой статье нет данных о пациентах.

Article submitted: 17.07.2023. **Accepted for publication:** 05.06.2024. **Published online:** 27.08.2024.
Статья поступила: 17.07.2023. **Принята к публикации:** 05.06.2024. **Опубликована онлайн:** 27.08.2024.