Open Journal of Modern Neurosurgery, 2026, 16(2), 182-192
https://www.scirp.org/journal/ojmn
ISSN Online: 2163-0585
ISSN Print: 2163-0569

Nakamura-Tracana Technique Based on Newton's Third Law Applied to Stabilize Hangman Type Iii Cervical Fracture: The First Case in Latin America

Yiro Nakamura Cardemil[1,2,3], Luis Tracana[1,2], Freddy Medina[1,2]

[1]Department of Neurosurgery, Dr. Luis Razetti Complex University Hospital, Barcelona, Venezuela
[2]Faculty of Medicine, University of Oriente, Barcelona, Venezuela
[3]Department of Neurosurgery, Dr Domingo Luciani Central Hospital, Caracas, Venezuela
Email: dryironakamura@gmail.com

How to cite this paper: Cardemil, Y.N., Tracana, L. and Medina, F. (2026) Nakamura-Tracana Technique Based on Newton's Third Law Applied to Stabilize Hangman Type Iii Cervical Fracture: The First Case in Latin America. *Open Journal of Modern Neurosurgery*, **16**, 182-192.
https://doi.org/10.4236/ojmn.2026.162017

Received: January 1, 2026
Accepted: February 23, 2026
Published: February 26, 2026

Abstract

Hangman's fracture or spondylolisthesis of the axis, are traumatic injuries to the C2 neural arch. They represent only 4% - 5% of cervical fractures, although they are often referred to as Hangman's fractures worldwide due to their radiological similarity. It is important to note that the two occur through different mechanisms. We report the case of a male patient in his thirties who, following a high-energy car accident and rollover, presented with polytrauma. Neurological examination revealed no motor deficits; only paresthesia in the right upper extremity was noted, with a GCS score of 15. A neurotrauma imaging protocol was performed, diagnosing a Hangman type III fracture. The patient was transferred to the ICU and traction (5 pounds) was applied using a Gardner-Wells frame. A follow-up cervical CT scan showed a reduction of the C2/3 segment. The patient was taken to the operating room while maintaining cervical traction. The surgical approach involved an anterior retropharyngeal cervicotomy, C2/3 discectomy, and fusion with a titanium cage and self-locking screw. During this surgical step, the locking screw of the cage did not fit the C2 body properly, as the craniocervical junction moved away when attempting to insert it. Therefore, in this work, we describe an ad hoc technique that, for the first time, allowed the placement of a self-locking screw in this pathology, thanks to Newton's theory of opposing vectors. After this surgical technique, the patient progressed satisfactorily with total reduction of C2/3 spondylolisthesis, great biodynamic stability, and a high level of fusion, with 24 months of postoperative follow-up without neurological deficits.

Keywords

Hangman Fracture, Cage, Self-Locking Screw, Opposing Vectors

1. Introduction

Hangman's fracture is a traumatic fracture of the axis. This is a traumatic spondylolisthesis of C2, that is, a bilateral fracture of the pars interarticularis and anterior subluxation of the C2 body over C3, preserving the position of the posterior arch. The fracture occurs at the widest point of the cervical spinal canal, as well as at the point of maximum canal-spinal cord ratio, which serves as an immediate decompression of the spinal cord. The term "hangman's fracture" has been used to describe two injuries with a similar radiological appearance, but resulting from two entirely different mechanisms and with very different clinical characteristics and prognoses. In medical literature, the first use of the term was by Haughton, who first described fracture-dislocations of the axis secondary to judicial hanging in 1866. This study was completed by Wood-Jones in 1913, who described the relationship between the position of the hangman's rope knot and the observed injury pattern, findings that were confirmed by Vermooten in 1921. This type of injury occurs through a hyperextension and distraction mechanism, with bilateral fracture of the C2 pedicles and complete destruction of the disc-ligamentous complex between C2 and C3. In more recent scientific literature, the term "hangman's fracture" is applied to an injury caused by a combined flexion or extension mechanism associated with axial loading. The most frequent cause is motor vehicle accidents. This injury consists of a fracture of the natural arch of C2, usually through both pedicles, with varying degrees of injury to the disc and ligamentous structures between C2 and C3, and generally has a better clinical prognosis. The injuries of the second type described were first mentioned in the literature by Grogono in 1954 as a result of a traffic accident. The term "traumatic spondylolisthesis of the axis" was applied by Garber, and the phrase "hangman's fracture" was used in 1965 by Schneider et al., which confused the classification, since the two injuries are markedly different in their mechanisms of injury, clinical characteristics, and associated injuries. Classification Type, Type 2 and Type 3. The classification of axis fractures was introduced by Effendi et al. and later modified by Lewine and Edwards. With two additional types (IA and IIA), the modified classification has five types [1] (**Figure 1**):

Anatomy and Biomechanics

If we consider the axis to be a transitional vertebra between the ring-shaped atlas and the rest of the cervical spine, which has a more conventional structure, acting as a pivot that allows rotational mobility of the skull and, in turn, as a lever arm that allows flexion and extension of the cranio-atlantoid complex on the relatively more fixed lower cervical spine, and which consists of a body to which the body of the atlas is attached (transformed into the odontoid process) and a neural

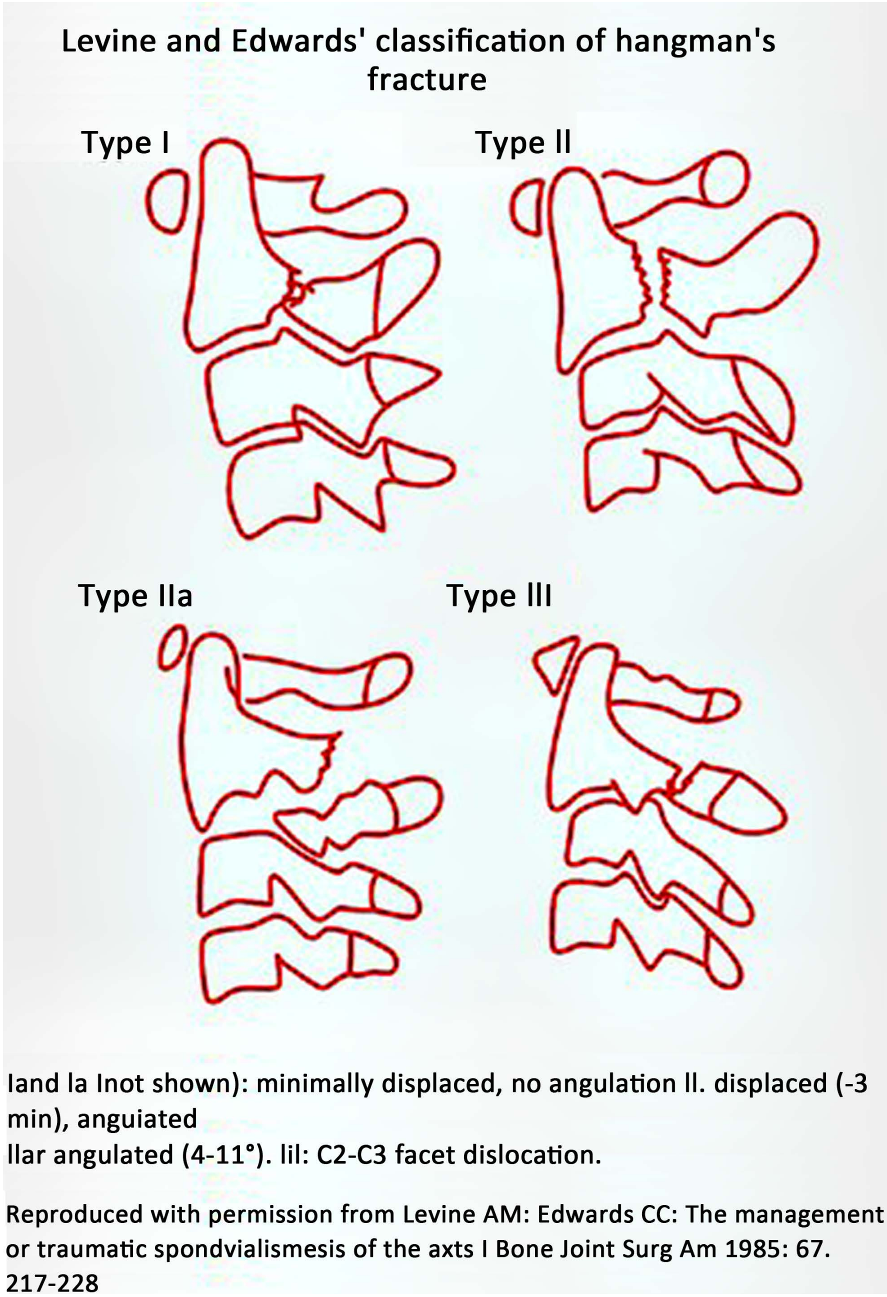


Figure 1. Shows the morphology of different types of Hangman fracture.

arch, which is relatively thin and long, and in turn attached to the posterior elements of the lower cervical vertebrae by a very resistant muscular and ligamentous complex, we can understand why the point of least resistance and the preferential site for injuries of this type lies in the junction of the body to the neural arch, since it is the site of least structural resistance of the complex. Additionally, the forces acting on the anterior and posterior elements of this structure tend to cause anteroposterior distraction of the complex when it is deficient or injured, potentially leading to instability in C2 neural arch fractures. The C2 pedicles are oriented 33˚ medially and 20˚ superiorly, with diameters of 7 to 8 mm in height and width, with slight variations between the sexes. Furthermore, the transverse foramina weaken the C2 neural arch because they are located at the base of the pedicles. The configuration of the articular facets is unique to the entire spine: the superior facets are convex and directed upward from medial to lateral, while the inferior articular facets are the same as those of the rest of the lower cervical spine [2].

Treatment [2] [3]

-Type I fractures < 3 mm of horizontal displacement: closed reduction followed by halo immobilization for 8 - 12 weeks, rigid cervical collar for 4 - 6 weeks.

-Type II fractures with 3 - 5 mm displacement: Type II reduction technique using combined axial traction and extension.

-Type IIA fractures: hyperextension (avoid axial traction in Type IIA). Operative reduction with surgical stabilization.

-Type III fractures with >5 mm displacement and severe angulation: Type III technique (facet joint dislocations): anterior interbody fusion C2-3, posterior fusion C1-3, C2, bilateral osteosynthesis with pars screws [2] [3].

2. Case Report

A male in his thirties presented with multiple injuries following a rollover motor vehicle accident. On admission, he had a Glasgow Coma Scale score of 15, no motor neurological deficits, and paresthesia in his right upper extremity. A polytrauma protocol with neuroimaging was performed, diagnosing a type III Hangman fracture with C2-C3 spondylolisthesis. Cervical traction was applied using a Gardner-Wells frame (5 lb), achieving initial radiographic reduction. (**Figures 2-4**)

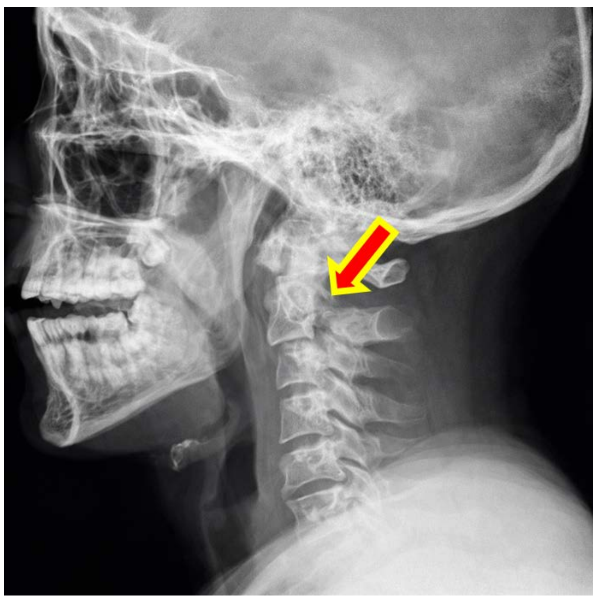


Figure 2. Shows Preoperative cervical Rx scan demonstrating a type III Hangman fracture. Sagittal reconstruction shows bilateral fractures of the C2 pars interarticularis with marked anterior displacement of the C2 vertebral body over C3, consistent with an unstable Levine–Edwards type III injury [4]-[6].

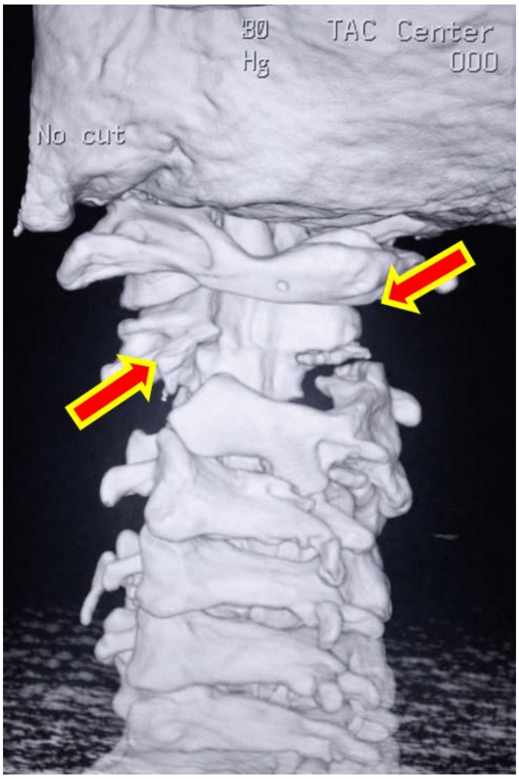


Figure 3. Shows Axial CT 3D image illustrating C2-C3 instability. Axial views confirm bilateral neural arch fractures of the axis (6.7).

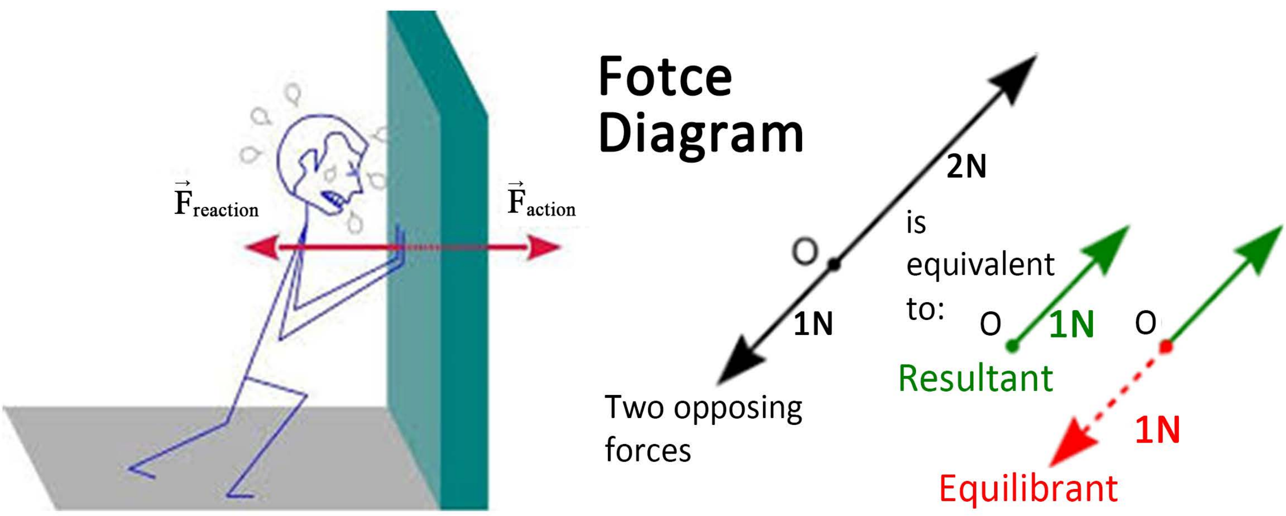
Figure 4. Shows Sagittal MRI image illustrating C2-C3 instability. Sagittal image demonstrate disruption of the C2-C3 disc space and associated spondylolisthesis.

3. Surgical Intervention

An anterior-retropharyngeal approach was performed, followed by a C2-C3 discectomy. An attempt was made to place a titanium cage with a self-locking screw in the C2 body. However, during the procedure, screw insertion caused displacement of the craniocervical junction and loss of reduction. An ad hoc Nakamura/Tracana technique was then developed, consisting This involves the surgeon using their dominant hand to grasp the screwdriver handle and the self-locking screw and applying force to screw in the cervical fusion cage, which would be the positive vector, while the assistant surgeon grasps the head and applies opposing force, which would be the negative vector, thus applying the law of opposite vectors or Newton's Third Law. That is to say of the simultaneous application of opposing force vectors (sustained distal cervical traction and ventral/instrumental force directed on C2 in a reverse craniocaudal direction) to maintain reduction during screw insertion and locking. This maneuver successfully achieved placement of the self-locking screw and C2-C3 fusion and stabilization (**Figure 5(a)**, **Figure 5(b)**, **Figure 6(a)**, **Figure 6(b)**).

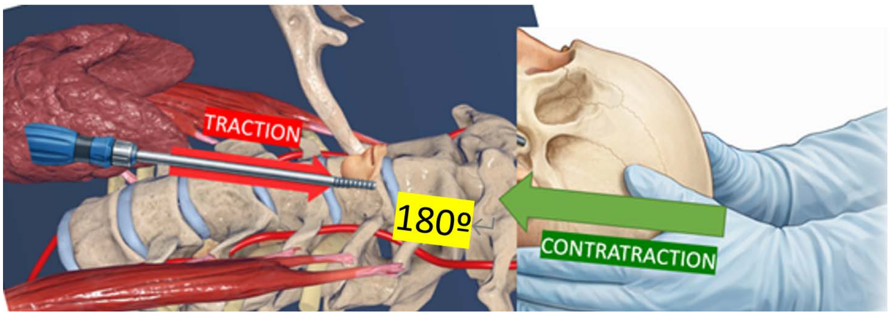
4. Results

Postoperative radiological examinations showed complete anatomical reduction of the C2-C3 spondylolisthesis and correct implant positioning. The patient progressed with improvement in the hypoesthesia present in his upper extremity prior to surgery, as well as improvement in his cervical pain. He was discharged 24 hours after surgery with a soft orthosis to be worn for 6 weeks. At 12 months, bone consolidation was excellent, with improved strength and neurological sensation; he presented no neurological deficits. Specialized outpatient follow-up was conducted 24 months after surgery, with complete recovery of neurological function (**Figure 7(a)**, **Figure 7(b)**, **Figure 8**).

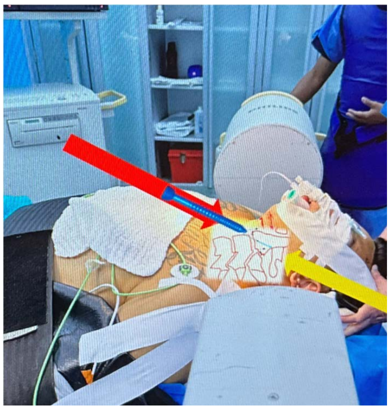


(a) (b)

Figure 5. (a) (b) Shows Opposite Vectors: Vectors with the same magnitude and direction, but in opposite senses (180 degrees difference).



(a)



(b)

Figure 6. (a) (b) Shows Intraoperative schematic representation of the Nakamura-Tracana technique. Illustration demonstrates the application of opposing force vectors during anterior C2-C3 fixation: a ventral craniocaudal force applied through the instrumentation (positive vector) and simultaneous distal cervical traction applied by the assistant (negative vector), in accordance with Newton's third law.

(a) (b)

Figure 7. (a) (b) Shows Immediate postoperative imaging following anterior C2-C3 fusion. Sagittal CT 3D scan shows correct positioning of the interbody cage with successful placement of the self-locking screw into the C2 vertebral body and complete anatomical reduction of the C2-C3 segment

Figure 8. Shows Long-term postoperative follow-up demonstrating solid fusion. Sagittal CT scan at 12 - 24 months reveals complete bony consolidation across the C2-C3 interbody space, maintained cervical alignment, and absence of implant failure or secondary displacement.

5. Discussion

Hangman type III fractures represent one of the most unstable patterns of traumatic spondylolisthesis of the axis due to the associated disruption of the C2-C3 disc-ligamentous complex and frequent facet dislocation. Although several surgical strategies have been described, including posterior fixation, combined anterior–posterior approaches, and isolated anterior fusion, there is still no universal consensus regarding the optimal technique, particularly in cases with marked craniocaudal displacement and intraoperative instability [7] [8].

Anterior C2-C3 discectomy and fusion has gained increasing acceptance for unstable Hangman fractures, as it allows direct disc removal, restoration of alignment, and immediate stabilization while preserving upper cervical mobility. Recent reports have demonstrated favorable outcomes using anchored or self-locking cages in this setting, providing adequate fusion rates and biomechanical stability while avoiding the morbidity associated with posterior or combined approaches. However, technical challenges may arise during screw placement, especially in cases with residual instability despite preoperative traction [9] [10].

In the present case, despite successful preoperative reduction using Gardner-Wells traction, intraoperative loss of reduction occurred during the attempted placement of the self-locking screw into the C2 body. This phenomenon highlights a critical but underreported limitation of anterior-only fixation in highly unstable type III fractures: the tendency for craniocervical distraction or posterior translation during instrumentation, particularly when axial and ventral forces are not adequately counterbalanced [11] [12].

The ad hoc Nakamura–Tracana technique described in this report addresses this limitation through the controlled and simultaneous application of opposing force vectors, in accordance with Newton's third law of motion. By applying sustained distal cervical traction while exerting a counteracting ventral force during screw insertion, reduction was maintained, allowing safe and accurate placement of the self-locking screw. This maneuver effectively transformed an unstable dynamic environment into a controlled biomechanical system, facilitating definitive fixation (**Figure 6(a)**, **Figure 6(b)**).

From a biomechanical standpoint, the axis acts as a transitional vertebra subjected to complex flexion, extension, and distraction forces. In type III Hangman fractures, the loss of posterior tension-band integrity and disc-ligamentous disruption predispose the C2-C3 segment to displacement when external forces are applied. The described opposing-vector technique counteracts these destabilizing forces in real time, maintaining segmental alignment during the most critical step of anterior fixation (**Figure 6(b)**).

Clinically, the patient achieved complete radiological reduction, solid fusion, and full neurological recovery at 24 months of follow-up, with no implant-related complications. These results are consistent with previously reported outcomes of anterior fusion techniques, while additionally demonstrating the feasibility of self-locking screw placement in scenarios where conventional methods may fail (**Figure 8**).

Nevertheless, this study has inherent limitations. As a single-case report, the findings cannot be generalized without caution. Furthermore, no formal biomechanical testing was performed to quantify the forces involved or compare this technique with alternative fixation strategies. Future cadaveric studies and biomechanical analyses are required to validate the reproducibility, safety, and mechanical advantages of this opposing-vector maneuver. Prospective clinical series would also be valuable to determine its role within the broader surgical algorithm for unstable Hangman fractures [11].

In summary, this report introduces a novel, simple, and reproducible intraoperative technique that may expand the applicability of anterior-only fixation in type III Hangman fractures. By leveraging fundamental biomechanical principles, the Nakamura–Tracana technique offers a practical solution to a challenging intraoperative problem and may contribute to safer and more effective surgical management of this complex injury pattern [11].

6. Conclusions

Hangman type III fractures represent a highly unstable injury pattern that poses significant challenges for surgical stabilization, especially during anterior-only fixation techniques. This case demonstrates that, in the presence of craniocaudal instability, conventional placement of self-locking screws in anterior C2-C3 arthrodesis can be compromised by intraoperative loss of reduction [11] [12].

The Nakamura-Tracana technique, based on the controlled application of opposing force vectors according to Newton's third law, allowed for the maintenance of cervical reduction during screw insertion and the secure placement of a self-locking cage in the C2 body. This maneuver provided immediate segmental stability, anatomical reduction, and successful arthrodesis, with excellent clinical and radiological results that were maintained during 24 months of follow-up. Although limited to a single case, this report suggests that the application of antagonist vectors during anterior fixation may be a useful adjunct in the treatment of unstable Hangman type III fractures and any fracture-dislocation from C2 to C7, potentially expanding the indications for anterior-only approaches. Further biomechanical studies and larger clinical series are required to validate the reproducibility, safety, and long-term efficacy of this technique (**Figure 6(a)**, **Figure 6(b)**).

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Ruiqiang, R., Yi, L., Haiyan, X., Minggui, W., Yixiu, L. and Song, S. (2025) Enhancing C2 Pedicle Screw Placement in Hangman's Fractures: A Comparative Study of Navigation and 3D Printed Guidance Techniques. *Frontiers in Surgery*, **12**, Article 1661304. https://doi.org/10.3389/fsurg.2025.1661304

[2] Pereira-Duarte, M., Gagliardi, M., Carazzo, C.A., Camino-Willhuber, G., Gotfryd, A., Rogers, M., *et al.* (2024) Comparison of Complication Rates between Anterior versus Posterior Approaches for Treating Unstable Hangman's Fracture. a Systematic Review and Meta-Analysis. *World Neurosurgery: X*, **21**, Article ID: 100245. https://doi.org/10.1016/j.wnsx.2023.100245

[3] Mahmoud, A., Shanmuganathan, K. and Montgomery, A. (2023) Surgical Management of Hangman's Fracture: A Systematic Review. *International Journal of Spine Surgery*, **17**, 454-467. https://doi.org/10.14444/8445

[4] Seo, H., Ko, J., Park, J., Kim, S. and Hwang, Z.O. (2021) Anterior C2-3 Fusion Surgery Alone for Highly Displaced Hangman's Fracture with Severe Angulation of C2-3 of More than 30°. *Clinical Neurology and Neurosurgery*, **206**, Article ID: 106701. https://doi.org/10.1016/j.clineuro.2021.106701

[5] Liu, J., Li, Y. and Wu, Y. (2013) One-stage Posterior C2 and C3 Pedicle Screw Fixation or Combined Anterior C2-C3 Fusion for the Treatment of Unstable Hangman's Fracture. *Experimental and Therapeutic Medicine*, **5**, 667-672. https://doi.org/10.3892/etm.2013.898

[6] Jeong, D.H., You, N.K., Lee, C.K., Cho, K.H. and Kim, S.H. (2013) Posterior C2-C3 Fixation for Unstable Hangman's Fracture. *Korean Journal of Spine*, **10**, 165-169. https://doi.org/10.14245/kjs.2013.10.3.165

[7] Li, G. and Wang, Q. (2023) Detailed Observation of Anatomical Location and Pattern in Hangman's Fracture Based on Computed Tomography Three-Dimensional Reconstruction. *Journal of Orthopaedic Surgery and Research*, **18**, Article No. 136. https://doi.org/10.1186/s13018-023-03622-x

[8] Murphy, H., Schroeder, G.D., Shi, W.J., Kepler, C.K., Kurd, M.F., Fleischman, A.N., *et al.* (2017) Management of Hangman's Fractures: A Systematic Review. *Journal of Orthopaedic Trauma*, **31**, S90-S95. https://doi.org/10.1097/bot.0000000000000952

[9] Botros, M., Singh, A., Shaikh, H., Ramirez, G., Molinari, R.W. and Puvanesarajah, V.

(2024) Atypical Hangman's Fractures: An Institutional Study of 51 Patients with Atypical Traumatic Spondylolisthesis of C2. *Global Spine Journal*, **15**, 175-183. https://doi.org/10.1177/21925682241284559

[10] Lu, Q., Tang, J., Xie, W., Mei, X., Kang, H., Liu, X., *et al.* (2024) Anterior Atlantoaxial Motion Preservation Fixation Technique for Axis Complex Fractures (odontoid Process with Hangman's Fractures) and Technique Notes. *Scientific Reports*, **14**, Article No. 687. https://doi.org/10.1038/s41598-024-51367-2

[11] Lee, S., Hur, J.W., Oh, Y., An, S., Yun, G. and Ahn, J. (2024) Current Concepts in the Treatment of Traumatic C2 Vertebral Fracture: A Literature Review. *Journal of Korean Neurosurgical Society*, **67**, 6-13. https://doi.org/10.3340/jkns.2023.0098

[12] Chen, Y., Luan, G., Li, X., Peng, Y., Li, T., Zhang, H., *et al.* (2022) C2-C3 Anterior Cervical Diskectomy and Fusion for Hangman's Fractures with C2 Posterior Dislocation: Technical Notes. *World Neurosurgery*, **158**, 210-215. https://doi.org/10.1016/j.wneu.2021.11.084