ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

DOI: 10.5336/medsci.2022-93200

Surgical Management of the Hangman's Fracture in the Twelve Cases: Case Series

On İki Vakada Hangman Kırığının Cerrahi Tedavisi: Olgu Serisi

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ABSTRACT Objective: Hangman's fracture is a condition characterized by anterior displacement of C2 upon C3 with a fracture in the C2 where the neural arch attaches to the vertebral corpus as a result of axial loading of the head accompanying hyperextension. **Material and Methods:** From January 2015 to January 2022, analysis retrospectively included 12 patients operated by hangman's fracture. The lesions were considered to be a hangman's fracture after computed tomography findings. The clinical condition was classified on the basis of American Spinal Injury Association scale and visual analog scale. All patients underwent C2-3 posterior fusion. All patients had at 6 and 12 months follow-up cervical computed tomography, which were used to assess bony union, final displacement, and angulation. **Results:** 5 of the patients were males and 7 females with the age range of 22-82 (mean age 49). The cause of trauma was in vehicle accident in 4 patients, falling from a height in 6 patients, and falling after slipping in the bathroom in 2 patient. All patients complained of neck pain. Except for 2 patients with upper extremity paralysis and spastic tetraparesis, 10 patients had no neurological deficit. According to the Levine and Edwards typical hangman's fracture classification, 7 had Type II fractures, while one patient had Type III fractures. According to the Li-Wang atypical hangman's fracture classification, 4 were Type B. **Conclusion:** Radiological evaluation and subsequent classification are very important in management. Posterior C2-3 fusion is a very effective surgical way.

Keywords: Axis; hangman's fracture; traumatic spondylolisthesis; upper cervical trauma

ÖZET Amaç: Hangman kırığı, hiperekstansiyona eşlik eden başın eksenel yüklenmesi sonucu nöral arkın vertebral korpusa tutunduğu C2'de bir kırık ile C2'nin C3 üzerine anterior yer değiştirmesi ile karakterize bir durumdur. **Gereç ve Yöntemler:** Ocak 2015'ten Ocak 2022 tarihine kadar geriye dönük olarak, hangman kırığı ile ameliyat edilen 12 hasta analiz edildi. Bilgisayarlı tomografi bulgularından sonra lezyonlar hangman kırığı olarak kabul edildi. Klinik durum Amerikan Spinal Kord Yaralanması Derneği skalası ve görsel analog skalasına göre sınıflandırıldı. Tüm hastalara C2-3 posterior füzyon uygulandı. Tüm hastaların 6 ve 12 aylık takiplerinde; kemik kaynaması, nihai yer değiştirme ve açılanmayı değerlendirmek için kullanılan servikal bilgisayarlı tomografi vardı. **Bulgular:** Yaşları 22-82 (ortalama yaş 49) olan hastaların 5'i erkek, 7'si kadındı. Travma nedeni 4 hastada trafik kazası, 6 hastada yüksekten düşme ve 2 hastada banyoda kayma sonucu düşme idi. Tüm hastalar boyun ağrısından şikâyetçiydi. Ekstremite paralizisi ve spastik tetraparezi kaybı olan 2 hasta dışında 10 hastada defisit yoktu. Levine-Edwards tipik hangman kırık sınıflamasına göre 7 hastada Tip II, 1 hastada Tip III kırık vardı. Li-Wang atipik hangman kırık sınıflamasına göre 4 tanesi Tip B idi. **Sonuç:** Tedavide radyolojik değerlendirme ve sonrasındaki sınıflandırma çok önemlidir. Posterior C2-3 füzyonu çok etkili bir cerrahi yöntemdir.

Anahtar Kelimeler: Aksis; hangman kırığı; travmatik spondilolistezis; üst servikal travma

Hangman's fracture is a condition characterized by anterior displacement of C2 upon C3 with a fracture (pars interarticularis or isthmus) in the axis (C2) where the neural arch attaches to the vertebral corpus as a result of axial loading of the head accompanying hyperextension. Because the cause of death during execution by hanging was the result of spondylolisthesis of the axis due to trauma, it was named hangman's fracture (hanged man syndrome) by Schneider et al. in 1965. Distraction accompanying hyperextension is responsible of the mechanism of the this situation after hanging.[1] Today, in-vehicle traffic accidents and head jumping into water are the most common causes of hangman's fractures. The axial load added when the neck is in hyperextension is responsible for the mechanism in these trauma

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Peer review under responsibility of Turkiye Klinikleri Journal of Medical Sciences.

Received: 05 Sep 2022 ***Received in revised form:*** 13 Oct 2022 ***Accepted:*** 14 Oct 2022 ***Available online:*** 01 Nov 2022

types, and bilateral fractures usually occur in the pars interarticularis (isthmus), which is the weakest part of the axis. In this case, it results in the displacement of C2 upon C3. In some cases, it is seen that hangman's fracture occurs when the neck is subjected to compression or flexion forces while in extension.[2,3]

Herein we presented to to review the records of clinical and operative findings 12 cases who had surgery for hangman's fracture. The preoperative preparation, surgical management, postoperative status, and follow-up for hangman's fracture are also discussed.

MATERIAL AND METHODS

From January 2015 to January 2022, analysis retrospectively included 12 patients operated by hangman's fracture. This research was reviewed by Alanya Alaaddin Keykubat University Clinical Research Ethics Committee (date: June 15, 2022, no: 05-04) and approval was obtained from this institution. The study was conducted in accordance with the 1964 Declaration of Helsinki and its subsequent appendices, and written informed consent was obtained from all patients in the study.

This study is retrospective and the clinic, radiology, surgery, and prognosis of the patients were examined. Patients were analysed based on the typical hangman's fracture classification system (Levine-Edward) and atypical hangman's fracture classification system (Li-Wang) (Table 1, Figure 1, Figure 2).[4,5] The lesions were considered to be a hangman's fracture after computed tomography (CT) findings. In addition, cervical magnetic resonance imaging (MRI) (for disc, ligament and cord injuries) and cervical lat-

TABLE 1: Typical and atypical hangman's fracture classification.

Classification	Definition and radiological findings	Mechanism
Levine-Edwards		
Type I	Vertical pars fracture just posterior to the C2 body ≤3 mm subluxation of C2 on C3 and no angulation	Axial loading and extension
Type IA	Fracture lines on each side are not paralell Fracture lines may pass through foramen transversarium on on side Anterior C2 body may be subluxed 2-3 mm anteriorly on C3 and C body may appear elongated.	May be hyperextension+lateral bending
Type II	Vertical fracture through pars Disruption of C2-3 disc and posterior longitudinal ligament	Axial loading and extension with rebound flexion
Type IIA	Oblique fracture (usually anterior-inferior to posterior superior) Little subluxation (usually ≤3 mm) but more angulation (can be 15°)	Flexion distraction (posterior arch fails in tension)
Type III	Type II+bilateral C2-3 facet capsule disruption C2 posterior arch is free floating Anteior longitudinal ligament may be disrupted or stripped off C3. Facets of C2/C3 may be subluxed or locked.	May be flexion (capsule disruption) followed by compression (isthmus fracture)
Li-Wang		
Type A1	Fracture line through the posterior aspect of the C2 body with contralateral pars fracture	Type A: combined forces of traditional components that cause typical hangman's fractures and a rotational component *Rotational injury force in Type A2 fracture might be stronger compared with that in Type A1.
Type A2	Fracture line through the posterior aspect of the C2 body with contralateral lamina fracture	
Type B1	Bilateral oblique fracture lines through the posterior aspect of the C2 body	Type B: combined forces of components that cause typical hangman's fractures, a rotational component, and a vertical compression that impact the parietal region of the head, and with the vertical compression force blocked by C2/3 facet joints, the complex of forces cause fractures in front of neural arch of axis. *Rotational injury force in Type B2 fracture should also be stronger compared with that in Type B1.
Type B2	Bilateral fracture lines through the posterior aspect of the C2 body, one is oblique and another is vertical	

*Rotational injury force.

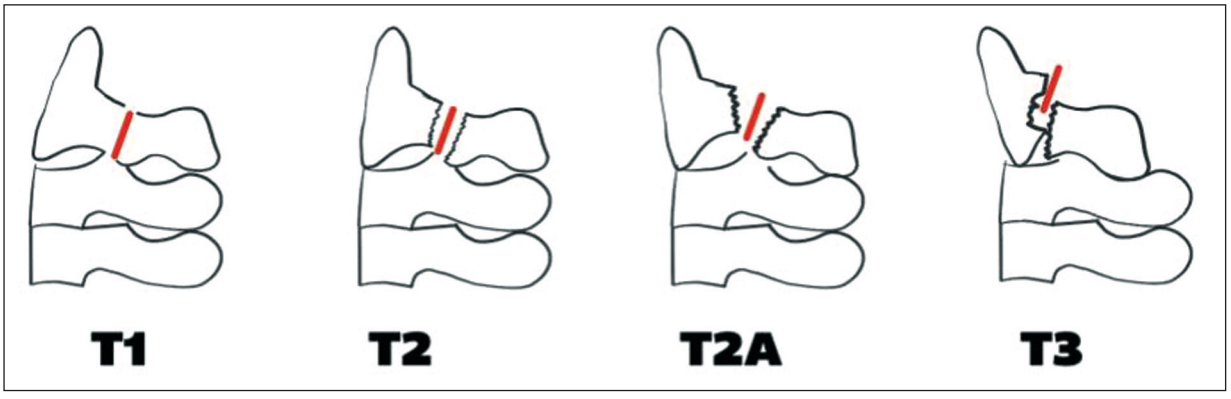

FIGURE 1: Levine and Edwards classification of hangman's fractures (modified Effendi classification).

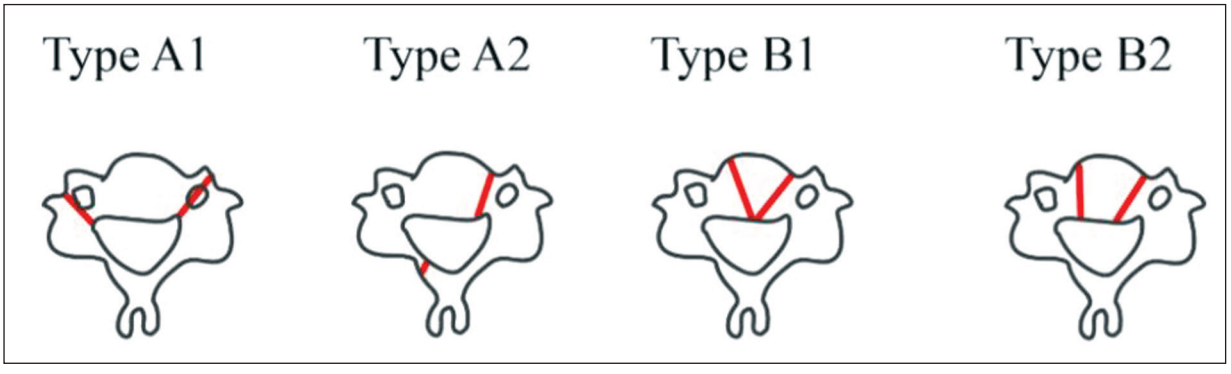

FIGURE 2: Li-Wang classification in atypical hangman's fractures.

eral radiography were performed on all patients. Patients who were followed conservatively without surgery were not included in the study. The current clinics of the patients were based on the American Spinal Injury Association (ASIA) scale and visual analog scale (VAS). Cervical traction with a weight of 2-3 kg was applied to all patients in the operating room, and then they were operated. C2-3 posterior fusion (C2 pedicular, C3 lateral mass screw) was performed in all of our surgical patients. The patients were followed at 6 and 12 months follow-ups, during which angulation, bone union and displacement awere evaluated with cervical CT. The presence of bone trabeculae between the C2-3 facets or the evidence of the presence of a gapless fracture line was thought to be fusion.

SPSS 25.0 (IBM Corporation, Armonk, New York, United States) program was used in the analysis. The mean VAS score and ASIA scale before and after surgery was compared using the paired t-test. A p value less than 0.05 was considered statistically significant.

RESULTS

There were a total of 12 patients, 5 men and 7 women. Their ages ranged from 22 to 82 years, with a mean age of 49. Details of a total of 12 patients are summarized in Table 2. The cause of trauma was in vehicle accident in 4 patients, falling from a height in 6 patients, and falling after slipping in the bathroom in 2 patient. All patients complained of neck pain. Except for 2 patients with upper extremity paralysis (Case 8, ASIA D) and spastic tetraparesis (Case 10, ASIA C), 10 patients had no neurological deficit (ASIA E). According to the Levine-Edwards typical hangman's fracture classification, 7 had Type II fractures (Figure 3), while one patient had Type III fractures. According to the Li-Wang atypical hangman's fracture classification, 4 were Type B (2 patients Type B1, 2 patients Type B2). Atlantoaxial dislocation was not detected in the dynamic radiographs of any patient. MRI showed cord contusion in one patient with multiple sclerosis (Case 10). This

TABLE 2: Details of the patient's clinical data.

Case number	Age	Gender	Type of trauma	Preoperative VAS	Postoperative VAS	ASIA scale	Preoperative ASIA scale	Postoperative ASIA scale
1	48	Male	Fall from height accident	7	2	Neck pain	E	E
2	33	Female	In vehicle accident	5	3	Neck pain	E	E
3	39	Female	In vehicle accident	5	3	Neck pain	E	E
4	34	Female	Fall from height accident	7	3	Neck pain	E	E
5	82	Female	Fall from height accident	8	2	Neck pain	E	E
6	58	Male	In vehicle accident	5	2	Neck pain	E	E
7	65	Male	Fall from height accident	8	2	Neck pain	E	E
8	45	Female	Fall from height accident	8	2	Neck pain	D	E
9	44	Male	Fall from height accident	8	1	Neck pain	E	E
10	49	Female	Bathroom slip and fall injuries	8	3	Neck pain	C	E
11	22	Male	In vehicle accident	4	2	Neck pain	E	E
12	69	Female	Bathroom slip and fall injuries	9	1	Neck pain	E	E

VAS: Visual analog scale; ASIA: American Spinal Injury Association.

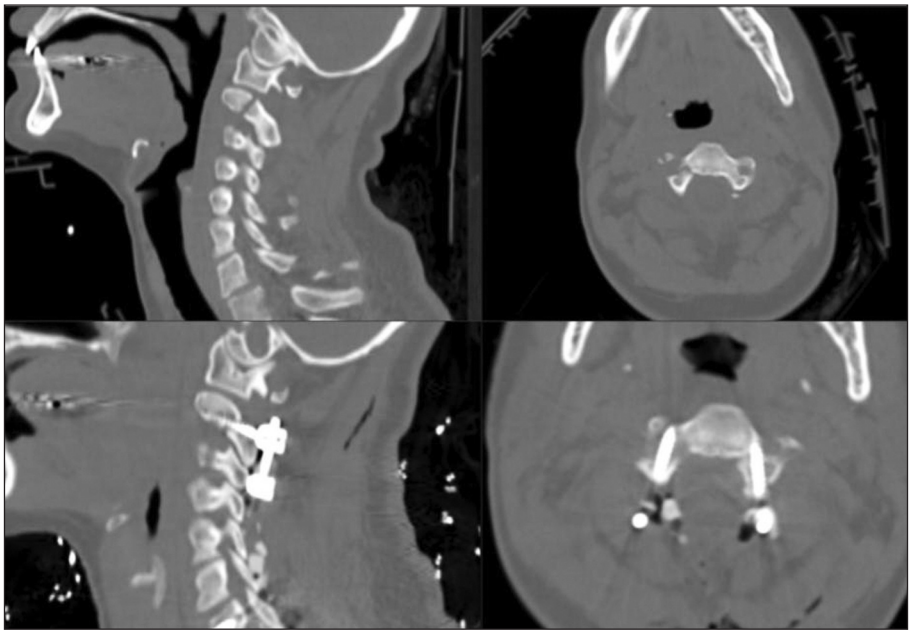

FIGURE 3: Type II hangman's fracture.

patient had 3/5 spastic tetraparesis, increased 4-sided deep tendon reflexes, bilateral Babinski and Hofmann signs. In all patients, the posterior longitudinal ligament was intact, while the anterior longitudinal ligament and disc were injured.

DISCUSSION

Hangman's fracture is constitutes 5-7% of cervical fractures. Most common complaint is neck pain. Neurological examination is generally normal.[1,2] Most commonly use three classifications for this fracture:

1. Levine and Edwards Classification (Modified Effendi classification)

2. Francis classification

3. Li-Wang Classification (Classification of atypical hangman fractures)

Cervical CT with sagittal and coronal reconstruction should be performed in all patients. The

condition of the C2-C3 disc in these fractures is important. Therefore, cervical MRI should be performed. CT angiography is useful if the fracture line extends into the foramen. Because there may be an injury to the vertebral artery.[4,5]

Fracture staging is important for surgery to decide on the treatment approach in Hangman's fractures. In order to make these decisions correctly, instability should be evaluated to ensure healing, subluxation measurement and degree of angulation should be performed, disc structure should be evaluated, in short, a good radiological evaluation is required. Fracture treatment approach is more successful with good radiological evaluation and staging. Appropriate treatment of hangman's fractures contributes to the surgeon optimizing patient outcomes.

In hangman's fracture, whether the fracture is stable or unstable is very important in planning the optimal treatment. Levine-Edwards Type I and most Type II fractures are stable, Type IIa and Type III unstable. Stable fractures, halo-vest can be treated.[4-7] 3 months of immobilization will be sufficient in the treatment of Levine-Edwards Type I fractures of Hangman fractures. In Type II fractures, if the subluxation is less than 5 mm and the angulation is less than 10; A halo jacket is applied early, after correction with cervical traction in slight extension of the head under close monitoring. On the contrary, injuries with unstable fractures give poor results if treated without surgery, but give good results with surgical intervention.[8] In addition to the authors reporting that the neck brace and halo are superior to surgery, there are articles in the literature suggesting early surgical treatments as soon as a fracture is encountered.[9-11] In addition, considering that neurological deterioration may occur in hangman fractures, patients should be followed up with strict neurological examination and observation. In Type I, which is a stable fracture, the patient can be mobilized early with an average of 2.5-3 months of immobilization and segment immobilization. However, surgery should be performed first in patients with intracanal disc and bone fragments.[10,11] Unstable fractures can be effectively managed with both anterior and posterior approaches with comparable clinical-radiological outcomes.[12] Traction should not be applied in Type IIA fractures as it may increase the deformity.

While anterior cervical discectomy and fusion is more effective in C2-3 disc, posterior approaches are more effective in isthmic injuries.[12,13]

Open reduction is recommended for Levine-Edwards Type III fractures because of facet locking. It has been reported in studies that both anterior and posterior approaches result in a high fusion rate and that both approaches do not seem to be superior to each other. Deciding to be stable or unstable in hangman's fracture difference types should be the first step in determining the most appropriate treatment to be applied to the patient.[13,14]

CONCLUSION

Radiological evaluation and subsequent classification (typical, atypical) in Hangman's fracture are very important in management. Posterior C2-3 fusion is a very effective method in terms of both clinical and radiological good results in surgery.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Özgür Akşan;* ***Design:*** *Özgür Akşan;* ***Control/Supervision:*** *Mehmet Seçer;* ***Data Collection and/or Processing:*** *Özgür Akşan;* ***Analysis and/or Interpretation:*** *Özgür Akşan;* ***Literature Review:*** *Mehmet Seçer;* ***Writing the Article:*** *Özgür Akşan;* ***Critical Review:*** *Özgür Akşan;* ***References and Fundings:*** *Mehmet Seçer;* ***Materials:*** *Özgür Akşan.*

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