Trauma
2016, Vol. 18(4) 250–254

DOI: 10.1177/1460408616639246
tra.sagepub.com
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Hangman's fracture from noose to neurosurgery

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Abstract

A fracture through the pars interarticularis of the axis is colloquially known as the 'hangman's fracture'. The origin of the name is self-explanatory; however, in modern times the hangman's fracture is rarely seen in suicide by hanging. This short article aimed at the non-spinal surgeon will take the reader through a brief timeline from the days of capital punishment to the modern day road traffic collision and the management of the hangman's fracture.

Keywords

Hangman's fracture, spinal trauma, spinal fractures, eponyms

Origins

The hangman's fracture is less dramatically known as 'traumatic spondylolithesthesis of the axis'. Simply, the injury is that of a 'fracture through the neural arch of C2 (pars interarticularis) with or without disruption of the C2–C3 articulation' (Figure 1).[1]

Although not named as a 'hangman's' fracture until the 1960s, the injury was first described in a 1913 Lancet article, grimly named 'the ideal lesion produced by judicial hanging'.[2] The article was written by Prof Frederick Wood Jones (Figure 2), a British anthropologist and director of the department of anatomy at the London School of Medicine for Women. Within the article he described the fracture dislocation of the axis seen in five sets of cervical vertebrae donated to the school by Captain C F Fraiser, the superintendent of Rangoon Central Jail in Burma in the 1910s. In this article, Wood Jones described the lesion being produced by the 'violent jerk which throws the man's head suddenly backwards'.[2] He further elaborated by explaining how submental placement of the hangman's knot is superior in causing instant death when compared to the sub-aural or sub-occipital knot that caused 'classical death' by strangulation. Wood-Jones noted that since the introduction of the 'drop' in 1818, previous knots were unsuitable and he advocated the use of the submental knot, to produce the hangman fracture causing immediate death, for use in future English judicial hangings.[2]

The term 'hangman's fracture' was not coined until 1965 when Schneider et al.[3] described a case series of eight patients suffering spondylolisthesis of the axis following road traffic collisions (RTCs). The origins of the paper began at a neurosurgical conference where two neurosurgeons presenting a series of clinical cases were approached by an anatomist. The anatomist was able to point out the similarities between the injuries in the case reports and those described by Wood-Jones in 1913.

As highlighted in the paper 'victims of judicial hanging are naturally not available for study', however, the authors were able to study the RTC patients and piece together the mechanisms leading to their injury. The mixed group of authors were described as having a 'profitable and harmonious collaboration' with clear descriptions of the injury, mechanism and outcome in the eight cases.[3]

Mechanism

Although first described following the sudden hyperextension observed in hanged criminals,[2] the hangman's fracture can be produced by either hyperextension or hyperflexion mechanisms.[4] The injury is hardly ever seen in suicidal hangings[5] presumably due to

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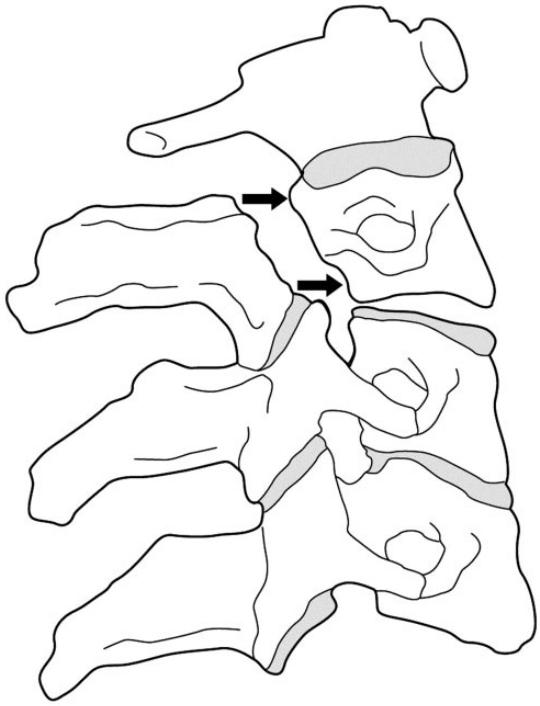

Figure 1. Traumatic spondylolisthesis of the axis. Image courtesy of A Dakin, Medical Illustrations, University Hospitals Birmingham.

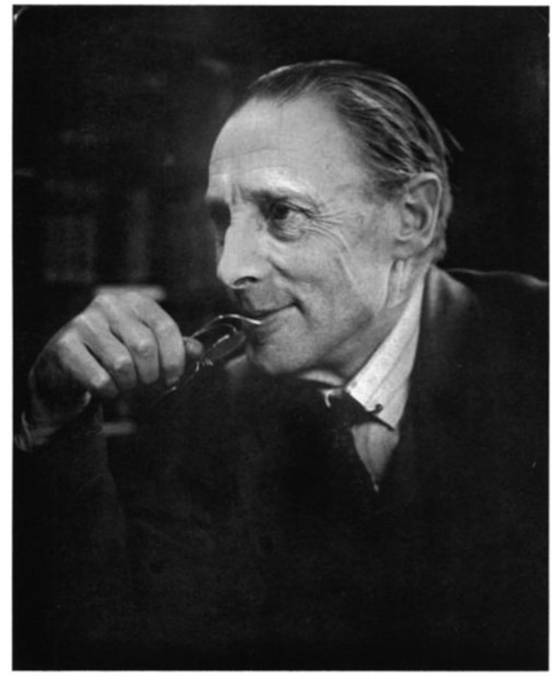

Figure 2. Prof Frederick Wood Jones, FRS (1879–1954).[3] © 1955 Anatomical Society of Great Britain and Ireland Photograph reproduced with permission from John Wiley & Sons Ltd.

the lack of the 'drop' described in Wood Jones' paper. In the modern day, the most common causes are RTCs, falls and diving into shallow water. The unrestrained driver/passenger is thrown forward hitting the dashboard or windshield creating a sudden, forceful hyperextension with axial loading. The same axial loading can be applied to the swimmer who dives into shallow water sustaining either a flexion or extension injury dependent on landing.[6]

Classification

Effendi et al.[7] described three types of traumatic spondylolisthesis of the axis based on mechanism of injury. This was modified by Levine and Edwards[4] with the addition of a type IIA injury.

Levine and Edwards[4] referred to a cohort of 52 patients with hangman's fractures. Of these, only four had neurological deficit and 11 had associated traumatic brain injury. Management of the fracture was determined by the type of injury and ranged from immobilisation in collar to internal fixation.

Twenty-nine percent of injuries are type I injuries.[8] These are defined as bilateral pedicle fractures with under 3 mm anterior displacement of the body of the axis and no angulation. While the forces of hyperextension and axial loading are enough to cause a fracture, there is insufficient force to cause disruption of the anterior or posterior longitudinal ligaments (PLLs) or the C2/3 intervertebral disc (Figure 3). With all of these structures intact, a type I injury is considered stable.[9] The majority (56%) of hangman's fractures are classed as a type II.[8] In comparison to a type I, a type II injury involves significant disruption of the PLL and C2/3 disc. This results in severe anterior displacement and angulation and is an unstable injury. A type IIA injury is caused by a flexion mechanism which results in less disruption of the PLL in comparison to a type II. Type IIAs have no anterior displacement but severe angulation and are hence considered unstable.[8,9] A type III injury is considered the most unstable injury as the fracture is associated with facet dislocation and therefore carries the greatest risk of morbidity and mortality.

Management

No Class I or Class II evidence exists regarding the management of traumatic spondylolisthesis of the axis (Figures 4 to 7). The Congress of Neurological Surgeons published an up-to-date systematic review of evidence in 2013; two recommendations were given. The first: initial management of the hangman's fracture should be external immobilisation, the second: surgical stabilisation and fusion are recommended in cases with severe angulation, disc disruption or inability to maintain fracture alignment with halo orthosis alone.[10]

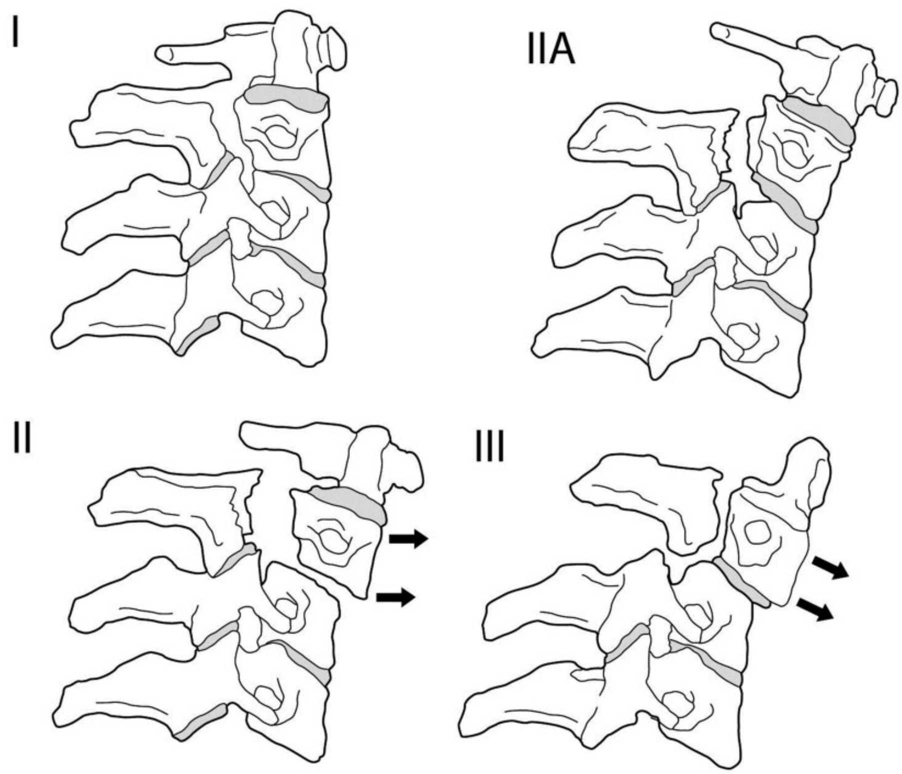

Figure 3. Levine and Edwards classification of traumatic spondylolisthesis of the axis\r\n. Image courtesy of A Dakin, Medical Illustrations, University Hospitals Birmingham.

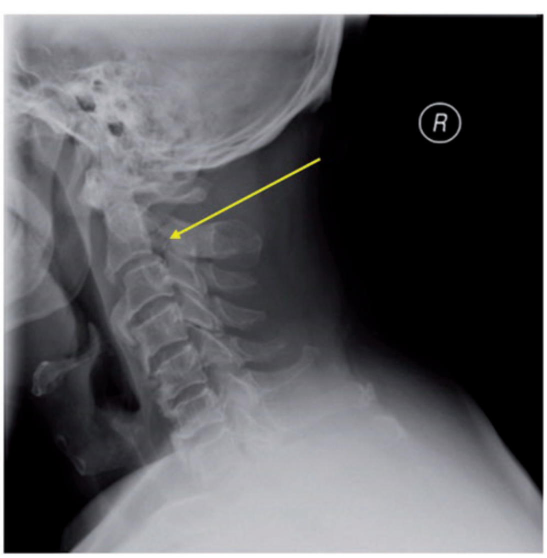

Figure 4. Lateral radiograph demonstrating traumatic spondylolisthesis of the axis.

Figure 5. Axial view of CT demonstrating traumatic spondylolisthesis of the axis.

External immobilisation may be achieved by use of cervical collar or the halo vest. Type I fractures are more typically managed in a hard collar for two to three months. Treatment of type II fractures is dependent on the level of displacement and angulation. Type II fractures with minimal displacement and angulation can be mobilised early in a halo vest, but more severely displaced injuries may require a period of traction prior to halo application. Traction is to be avoided in

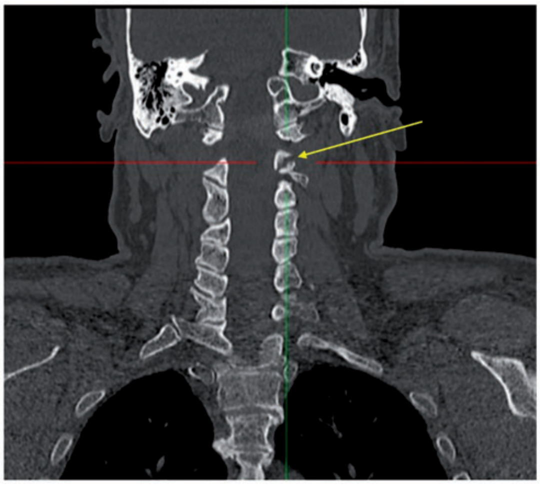

Figure 6. Coronal view of CT demonstrating traumatic spondylolisthesis.

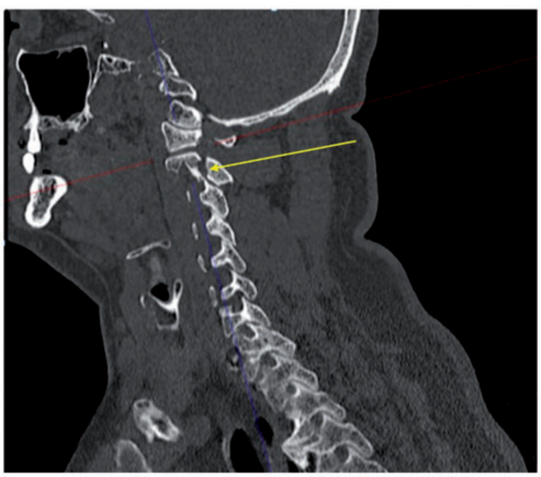

Figure 7. Sagital view of CT demonstrating traumatic spondylolisthesis.

type IIA fractures[7] and the neck should be held in slight extension and compression. Although rates of fusion are high following non-operative management, increased angulation appears to be associated with higher non-union rates.[11,12]

Surgical management of the hangman's fracture should be reserved for cases of non-union and the most unstable injuries where fracture reduction is not maintained by non-surgical means. Anterior stabilisation is preferred due to ease of access compared to more complex approaches such as transoral or retropharyngeal. Posterior stabilisation is necessary in circumstances including: locked facet joints or irreducible fractures, compressed vertebral artery, associated fractures of C1 requiring stabilisation or any contraindication to performing an anterior approach. In addition to minimising damage to the anterior ligaments, posterior stabilisation has the advantage of correcting any kyphotic deformity. Inclusion of atlas into the instrumentation may necessitate early implant removal due to severely reduced rotational ability.[13] Direct screw osteosynthesis is a more complex procedure, where bilateral lag screws are introduced via the pedicles; however, this does not address instability caused by ligamentous injury and so is only suitable for type I or more stable type II injuries.[13]

Prognosis

Short-term problems mainly involve complications with treatment such as pressure sores from collars, halo pin loosening, pressure sores and post-operative infection.[1] Twenty-one percent of patients with hangman's fracture have an associated traumatic brain injury[4] complicating management especially if traction or halo is required. Fusion rates are high with up to 95% in halo orthosis alone.[14]

Table 1. Levine and Edwards classification of hangman's fracture.[4]

Type	Stability	Mechanism	Radiological features: Anterior displacement	Radiological features: Angulation	Radiological features: Facet dislocation	Management
I	Stable	Hyperextension-axial loading force	<3 mm	No	No	Collar immobilisation
II	Unstable	Hyperextension-axial loading force rebound flexion	>3 mm	Yes	No	Reduced in halo and immobilised in halo jacket
IIA	Unstable	Flexion-distraction	No	Yes ++	No	Reduced with extension and compression in halo vest
III	Grossly unstable	Flexion compression	<3 mm	No	Yes	Internal fixation

Summary

Although 'hangman's fracture' rolls off the tongue with considerably more ease than 'traumatic spondylolisthesis of the axis,' the injury is hardly ever seen in cases of hanging in the modern day. The fracture is most commonly caused by RTC and diving accidents and fortunately is rarely associated with neurological deficit in those who survive. Classification is dependent upon anterior displacement of the vertebral body, angulation and facet dislocation. A range of management options is available from collar to internal fixation and despite its formidable colloquialism, the long-term outcome of the hangman's fracture is good.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Provenance and peer review

Not commissioned, externally peer reviewed.

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