Letter to the Editor concerning: A systematic review of the management of hangman's fractures by Xin-Feng Li et al. (2006) Eur Spine J 15:257–269

Heiko Koller · Anton Kathrein

Published online: 14 July 2006
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Early in the last century several authors (Grogono 1954; Rogers 1957; Norton 1962; Ramadier 1963; Garber 1964; Schneider 1965) observed similarities in the fracture pattern of the axis vertebra and that in hanged men described by Wood Jones on specimen of criminals. Since then, more than 200 articles, textbooks, and podium presentations worked up this interesting fracture entity [5]. We therefore read the well-structured review [7] concerning management of hangman's fractures (Hmfx) and traumatic spondylo-lysthesis (TS_{C2-3}), with great interest.

According to the authors' observations, systematic reviews and meta-analyses become an increasingly accepted means of achieving evidence-based conclusions [7]. The same has been done for Hmfx previously [1, 2], leading to similar results compared to that of the current authors. Unfortunately, in line with the fate of some current reviews of literature, the latest review too lacks a comprehensive database: it draws conclusions from classifications which have been widely adopted but seldom questioned; it lacks critical scrutinizing of reviewed results and treatment algorithms; and it neglects the functional aspects of outcome (e.g. range of motion, pain, discomfort, time for rehabilitation and return to work, time of immobilization in the HALO or traction devices)—although this is given in some more recent works (Moon 2002; Junge 2002; Palta

1999; Lucke 1999; Peterson 1994) [5, 6]. The latter fact particularly deserves credit, as decision-making process, treatment, and clinical outcome of Hmfx, for example, can be influenced by associated polytrauma, which is present in 10–56% of all Hmfx [6]. The authors state that the current literature was examined to determine the evidence for the management of Hmfx. Unfortunately, the review works on a small sample, excluding non-English articles. If one is performing a systematic review of the literature, more abstract reviewing, Internet research, and translation should be performed nowadays.

The authors conclude from their study that the classification system proposed by Effendi and modified by Levine might be suitable as a guide for the management of Hmfx. However, in the beginning the authors suggest that surgical indications for Hmfx are still controversial. Indeed, the applied classifications are to be debated controversially, as for example a classification scheme based on morphometric data has been validated only once in literature, showing its insufficiency [6]. It is of importance to differentiate stable Hmfx from unstable ones, e.g. using dynamic films, in-hospital clinical course with X-ray control during wear of a cervical collar, or at least using MRI, and not applying definitions based on morphometric measurements suggesting instability, in which the definition of instability varies between 1 and 8 mm of translation and 5° and 30° of angulation on plain X-rays. Morphometric definitions of instability are questionable concerning the laws of trigonometry in common X-ray techniques and the fact that plain X-rays can only document fracture instability at one point of diagnostics. We therefore demonstrated that intraoperative findings in unstable Hmfx correlated poorly to radiographic, static mea-

The article to which this letter refers can be found at <http://dx.doi.org/10.1007/s00586-005-0918-2>

H. Koller (✉) · A. Kathrein
Department for Trauma Surgery and Sports Medicine,
Medical University Innsbruck, 6020 Innsbruck, Austria
e-mail: heiko.koller@t-online.de

surements, but showed that there is no correlation between slight or even more severe displacements and the morphological situs intraoperatively [6].

The review concerns outcomes based on classifications (Effendi/Levine) which are worse validated, but applied in almost all papers, lectures, and textbooks dealing with Hmfx. The merit of Effendi et al. [3] was to mention and imply concerns about the dynamic instability of C2–3 to treatment decision-making in Hmfx. But, concerning Levine's article and its modified classification, which describes distinct instability patterns of C2–3 according to supposed intact or disrupted discoligamentous elements of C2–3, one has to consider that Levine did not approach anteriorly to treat alleged unstable Hmfx operatively. Intraoperative evidence, on the assumption that discoligamentous elements are supposed to be ruptured or intact radiographically, could not be given. However, numerous authors observed that even though there was a radiographically stable Hmfx, intraoperatively or in post-mortem studies the C2–3 complex was unstable due to discoligamentous complete or incomplete disruptions or avulsions of the longitudinal ligaments from the vertebral cortices of C2–3 (Cornish 1968; Norell 1970; Buchholz 1981; Pepin 1981; Tuite 1992; Sherk 1983; Feeser 1997; Wilson 1999; Bühren 2002) [5, 6] (see Fig. 1). Unfortunately, although frequently recommended, dynamic X-rays or MRI were seldom performed on a regular basis in published articles. Therefore, the given incidences of stable and unstable

Hmfx are to be questioned [6]. Accordingly, as the authors recognized [7], most often rupture of the disc or anterior longitudinal ligament could only be concluded from the narrowing of disc space with osteophytes and spontaneous fusion of C2–3 for the combined damage to disc and ligaments (Brashear 1975; Lucke 1999) [6]. Using Effendi's and Levine's classification, it is therefore difficult to answer the question whether the initially treated fracture was an Effendi/Levine type I, II, or IIa. Accordingly, the list of secondary failures following primary intended conservative treatment in alleged stable Hmfx and Effendi type I/II fractures, respectively, is quite long [6]. The difficulties in the diagnosis and management of Hmfx are illustrated by the fact that we found more than 30 papers which report secondary change of primary intended, but failed conservative, treatment to surgical repair in alleged stable Hmfx [6].

In between the family of axis fractures, the differentiation between vertebral body fractures C2, combined axis fractures, as well as classic and atypical Hmfx has been somewhat watery in the literature. Actually, combined Hmfx (with other C1- and C2-fractures) accounts for 7–76% of all Hmfx, and atypical Hmfx can be observed in about 50% [4, 6], whereas conservative treatment of atlantoaxial fracture combinations show failure rates up to 50% [1, 2, 6]. Within the unstable TS_{C2–3}, defined as discal- and/or discoligamentous injury of C2–3, a large number of atypical variants exist, in which fracture lines affect any part of the axis vertebra (Fig. 2) [6]. As part of atypical Hmfx (not the classical bilateral fracture of the pars interarticularis), intraarticular fracture lines can show the tendency of decreased functional outcome in Hmfx [6]. Intraarticular fracture variants were first observed by Jeanneret (1985) and confirmed by Benzel (1994), Josten (1998), Samaha (2000), and Junge (2002) [6]. Atypical fracture variants can be subclassified into the family of stable and unstable Hmfx (Fig. 2), but each fracture configuration can encounter special patterns of instability, and demands individually shaped solutions for treatment. For example, fracture and/or collapse of the lateral mass of C2 (Ferrer 2001; Fujimura 1996) [6], or associated fracture of the vertebral body C2 [6], can lead to operative treatment even in stable Hmfx [6]. Also, discal- and discoligamentous unstable, atypical Hmfx with a fixed posterior wall of C2 can show dislocation of the anterior vertebral body fragment of C2 on C3 with spinal cord impingement between the posterior wall of C2 and posterior atlas arch (Burke 1989; Starr 1993) [6]. If alleged stable, these Hmfx can show catastrophic results with primary conservative therapy. Unfortunately, these observations were not

Fig. 1 *Left* lethal, discoligamentous unstable Hmfx: cadaver cryosections showed the disc rupture, as well as avulsed anterior and posterior longitudinal ligaments, encountering translatory instability. The latter would not be detected in MR imaging studies. *Right* an intraarticular fracture course in this atypical Hmfx. Source: [5]. (With permission of publisher: Georg Thieme KG, Germany)

Fig. 2 In general, discoligamentous stable and unstable Hmfx exist, with/without uni- or bilateral facet dislocation. However, besides the classical bilateral fracture of the pars interarticularis, various atypical Hmfx exist, including distinct fracture variants. The latter can alter and impede decision-making process in Hmfx: Hmfx with uni- or bilateral intra- or extraarticular fracture traces (blue in **b**, **c**, and **d**, respectively); a remaining fixed posterior wall of C2 (red in **a**, **d** and blue in **b**); fracture

trace posteriorly, inside, or anteriorly to the inferior, dislocated, facet (blue, green, and red in **a**); three- and four-part Hmfx with further fracture components, such as odontoid fracture or fracture of the vertebral body of C2 (blue and red in **e** and **f**); fracture, or fracture separation, of the entire C2-pedicle (red in **c**) or the lateral mass of C2 (green in **c**); impression fracture of the lateral mass of C2 (not shown). Source: [5]. (With permission of publisher: Georg Thieme KG, Germany)

picked up in the review. However, these subtle differences have to be studied thoroughly in future research to adapt treatment algorithms and evaluate outcome.

The smallest denominator in classic and atypical, unstable Hmfx is the ruptured disc with or without avulsed or ruptured anterior and posterior longitudinal ligament. Hmfx can affect any part of the axis vertebra, which is not reflected in the widely applied classification of Effendi and Levine, but observed in several cited articles. Neglecting these observations can mislead colleagues when applying the conclusion of the given review in clinical practice.

Based on an own review of literature [5] more than 50 authors present 40 different concepts for therapy of Hmfx. These comprise the whole spectrum of conservative and operative techniques for stabilization of C1–3, combination of both conservative and surgical treatment, and controversies between primary or only secondary operative treatment after failed conservative immobilization. The duration of applied conservative external treatment methods reported in the literature varies between 4 and 20 weeks with the cervical collar, the HALO device, or prolonged tong traction. In the given review, an anterior and posterior approach was recommended for ‘unstable Hmfx’ and the authors noted that for operative treatment, fusion and stabilization were predominantly achieved with the use of

posterior approach for type II fractures. However, one has to emphasize that these approaches frequently incorporated Judet’s technique or C0–2 and C1–3 stabilizations, in which the former does not address segmental instability of C2–3, questioning the evidence of real discoligamentous instability of C2–3 in the context of an unstable TS_{C2-3} in these cases, and the latter present some kind of overtreatment eliminating motion of C1–2. Judet’s technique is reserved for discoligamentous stable TS_{C2-3} , and particularly for cases with a stable posterior ligamentous complex C2–3 and C1–3. Could, and was, the latter foreseen preoperatively in those cases in which Judet’s technique was applied? Also, this technique overcomes its limits in atypical Hmfx with fracture lines tracing the vertebral body of C2 far anteriorly. In such cases, grasping of anterior fragments can be difficult using bilateral transpedicular screw fixation of C2 (Samaha (2000) [6]).

There are specific indications for a posterior approach in Hmfx, e.g. in cases with encroachment of the neuroforamen of C2–3 due to facet fragments, non-reducible dislocations of C2–3, contraindications for anterior approach, and a few others. However, Lohnert (2002) [6] applied various operative treatment methods and concluded that anterior decompression and fusion of C2–3 is the ideal technique for unstable Hmfx.

Accordingly, crop-damage and inferior functional results after posterior approaches to the upper cervical spine are known concerns. We are surprised that we found more than 20 articles with considerable number of patients reporting successful radiological and clinical outcomes after anterior fusion of C2–3. Some good to excellent results after anterior fusions of C2–3, not cited in that review, were easily found at least in abstracts (Chen 2004 from China; Kocis 2003 and Lohnert 1993, 2002 from Czechoslovakia; Fuentes 2003 from France; Koller [5] from Austria; Junge 2002 and Peterson 1994 from Germany, etc.) [6], emphasizing the benefits of this kind of primary intended treatment for unstable discoligamentous Hmfx.

Unfortunately, no comment was given on the functional outcome after posterior fusion of C2–3 or with the Judet's technique. Clinical outcome and subaxial segmental range of motion after anterior fusion of C2–3, even though seldom measured (Peterson 1994; Verheggen 1998; [5]), can be superior to conservative treatment [6]. The success of treatment in the discussed systematic review was limited to the observation of osseous union of C2 or fusion of C2–3.

We dare to ask why there was no discussion on the drawbacks of some conservative treatments, such as with the HALO device or tong traction, applied during the maturation of fracture healing in stable Hmfx, or until fibrous and/or osseous union of C2–3 in unstable Hmfx. The drawbacks of anecdotal prolonged traction or the HALO device and the functional outcome in patients treated with cervical collar, prolonged traction, the HALO device, or operative stabilization were not discussed, but can be considered.

Anterior fusion of C2–3 is a superior conservative treatment in unstable Hmfx. In skilled hands, the latter offers our patients high primary stability, a high union rate in almost 100% of patients, anatomical reduction with reconstruction of cervical lordosis, favourable clinical outcome, and avoidance of secondary salvage fusions after primary intended failed conservative treatment [4, 6]. The latter can be strenuous and less successful.

The authors also state that healing in a malunion position with anterior displacement was common with conservative treatment and it may be not harmful [7]. Indeed, accurate fracture reduction and realignment of C2–3 was seldom achieved in conservative treatment of unstable Hmfx (Green 1997; Lucke 1999) [6]. However, in the series of Tuite (1992) [6] many patients with spontaneous fusion of C2–3 in subluxated position complained about pain. Similar observations are documented in the excellent works by Lucke (1999), Palta (1999), and Peterson (1994) [6].

In Hmfx, stability should be discussed regarding discal and discoligamentous integrity. These pathomorphological findings have to be assessed prior to treatment of Hmfx using dynamic X-rays, MRI, or at least with observation of clinical and radiological course during some in-hospital days in the cervical collar.

Atypical and combined Hmfx has to be differentiated as they can bedevil conservative treatment and clinical outcome in discoligamentous stable Hmfx.

From the results of their review the authors conclude that rigid immobilization (as with tong traction or the HALO device) might be necessary for most Hmfx. In our terms, in 2006 within modern cervical spinal surgery and within otherwise 'healthy' patients, there is no place to apply a HALO device for 12 weeks or tong traction to treat unstable Hmfx. In skilled hands, anterior fusion of C2–3 for unstable Hmfx of C2–3 provides superior functional and radiological results with highest fusion rates [6], whereas a semirigid cervical collar is a sufficient treatment for the 'real' discoligamentous stable Hmfx.

The authors added a well-structured and written systematical review of literature concerning Hmfx to the English literature. However, as interested readers we do not demand 'statistical evidence' for treatment decision-making only, but also demand critical interpretations of a large number of reviewed articles. Particularly, the kind of failures in some treatment options and the drawbacks of these failures to our patients should be weighted more in future reviews.

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