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INSTRUCTIONAL LECTURES & PANEL PRESENTATIONS

THE ROLE OF MRI IN THE CLASSIFICATION OF THORACOLUMBAR SPINE INJURIES

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Thoracolumbar spine fractures are complex injuries of a structure, which is compose of parts with different susceptibility to injury and different healing potentials. This complexity is reflected in the difficulties with the classification attempts and in the confusion in the literature about the effectiveness of different treatment regimes. Remarkable differences in the long-term results of conservative treatment regimes or surgical methods have been reported in the literature. These difficulties were probably caused by inadequate definition of some of the essential prognostic parameters. Since Holdsworth (1963), architectonic abstractions such as column have been used to comprehend these complex injuries and their mechanical consequences In the two-column spine of Holdsworth and the subsequent three column spine concepts of Louis (1977) and Denis (1983), the non-osseous structures of the spine were considered integral parts of these columns. The integrity of soft tissue structures, however, could only be inferred from indirect evidence from radiograms and later from CT scans. The Denis classification has been quite influential. Although this classification was a refinement in the understanding of the nature of these injuries, it was amenable to many simplifications and led to some persistent confusion. Although Denis emphasized that his columns are formed by osseous and non-osseous structures, no attempt has been made to progress the diagnosis of non-osseous injuries. The three-column concept was reduced to what is imagable with CT. It has been simplified and reduced to a simple rule of the thumb, which states that any injury to two of the three columns, as seen on CT, i.e. bony injury, make the spine unstable. Further, an intact middle column has been seen as a guarantee of stability, although Denis mentioned some of these lesions as first-degree unstable. Also the differentiation between the first, scond and third degree instability was lost, leading to a vague, poorly defined instability concept, which has remained dominant during the past decade.

Despite its widespread acceptance there have been criticism of the Denis classification and attempts to modify it. Ferguson and Allen (1984) called the columns a poor semantic choice because these tissues do not anatomically ofr biomechanically resemble a column. They claimed that “the term, although appealing for its verbal ring, is anatomically and biomechanically incorrect.” They suggested a mechanistic classification in stead according to a presumed mechanism of injury deduced from the patterns of tissue failure. McAffee et al (1983) suggested a division of the burst fractures as stable und unstable. McCormak et al proposed the load-

sharing classification in 1994. This proposal was a specific elaboration of the Denis system with a specific problem in mind. The authors were disturbed by the high rate of failure of posterior fixation in their patients with three column fractures and fracture dislocations, and searched for factors predictive of this failure. Their conclusion was that the degree of comminucation of the vertebral body together with apposition of fragments and the degree of deformity correction was a factor predictive of the failure of posterior fixation.

The most sophisticated classification system, which has been proposed to date, is the Comprehensive Classification presented by a committee of the AO foundation on this subject (Magerl et al 1994). In this scheme there are three main types of injury, defined by common morphologic characteristics and a common injury producing force. Extent and direction of soft-tissue injury are the main determinants of these types. Type a injuries represent vertebral body compression caused by axial load with or without an element of flexion but without disruption of soft-tissues in the transverse plane. Type B injuries are anterior and posterior element injury with distraction, representing soft-tissue disruption in the transverse plane. Type C injuries are anterior and posterior element injuries with rotation. Each type is further subdivided into groups and subgroups using the common AO 3-3-3 grid. The A 1 subgroup correspond to the “wedge fracture” and 3 to the “burst fracture” of the Denis classification. The bony involvement in Type B and C fractures follows essentially the subdivision of the Type A fractures. The involvement of soft-tissues, which is the key determinant in type level of classification, was indirectly deduced from radiograms and CT scans in the original series of the authors. although this scheme is very elaborate and allows a detiailed analysis of the fractures, its relative complexity makes it prone to problems of reproducibility. A recent study showed poor reproducibility of the type level classification of this scheme with radiograms and CT’s alone, which improved with the use of MRI (Oner 2002).

It is clear that many authors feel that soft tissue injury patterns are essential prognostic parameters. But these parameters have been poorly defined due to diagnostic difficulties. A reliable clinical examination of the soft tissue involvement is not possible in the thoracolumbar spine. Radiograms and CT’s provide only indirect evidence of soft tissue involvement. MRI has been shown to be capable of depicting ligamentary injury associated with these fractures in clinical and experimental studies. Petersilge et al reported on MRI’s of 25 “burst fractures” according to the definition of Denis. They found in seven of the fractures posterior ligamentary disruption, which would be unsuspected on radiograms and CT scans. Terk et al report detection with MRI of posterior ligamentary complex injury in 36 of the 68 fractures studied. Leferink et al (2002) found in 1/3 of their operatively treated patients posterior ligamentary complex injury unsuspected on radiograms and CT’s. Another study by ur group showed the prognostic importance of changes in the disc space, especially in the conservatively treated patient, and classified these changes on MR images (Oner 1998). There are two cadaver studies, which showed excellent correlation between MR images and anatomic sections. Kliewer et al (1993) showed in a cadaver study good correlation between MR images and anatomic sections of acute spinal ligament disruption. In a similar study Oner et al (1999) reported perfect correlation between MR images and anatomic sections of injuries to the discs and endpla-

tes. These studies establish MRI as a highly accurate modality for determining disco-ligamentary injury patterns and describe the MRI features of different structures involved.

We attempted to clarify these issues in a prospective study using MRI's in a consecutive series of patients. We categorized the MRI findings of all relevant structures in a sample of 100 patients (Oner 1999) (Fig. 1). A wide variation of different injury combinations was seen in this study. The crucial question is which of these injuries have prognastic significance and whether these injury patterns can be captured with existing classification systems. In a consequent prospective study of 53 patients (Oner 2002) we found that unfavorable outcome in the conservative group was related to the progression of kyphosis, which in most cases was predictable with the use of trauma MRI findings concerning the EP and COR involvement. In the operatively treated group, recurrence of the kyphotic deformity was predictablely the lesion of the PLC together with endplate comminution and vertebral body involvement as seen on trauma MRI. These studies confirm the value of the mechanistic classification of the Magerl system and the load-sharing classification, which can be combined in order to develop schemes with higher predictive value.

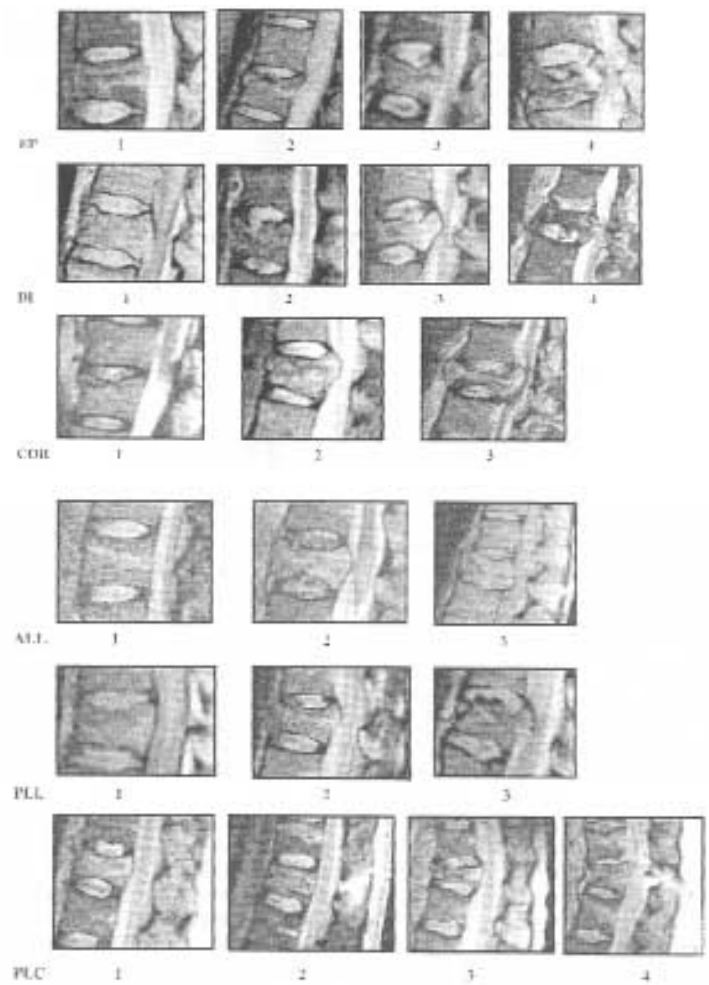


Figure 1: States of the ligamentary structures endplates, discs and vertebral bodies observed on the MRI's. ALL: Anterior Longitudinal Ligament; PLL: Posterior Longitudinal Ligament; PLC: Posterior Ligamentary Complex. EP: Endplate; DI: Intervertebral Disc; COR: Corpus (Vertebral bodiy). (Oner 1999).

Recommendations

Mechanistic classification schemes are the best tools to conceptualize the spinal injuries and to develop prognostic means. A classification system is valuable a long as it can be used as a prognostic tool and can be refined with reassessment by the users. At this moment, the best conceptual scheme for thoracolumbar fractures is the Comprehensive Classification based on the mechanical model of a crane (Fig. 2).

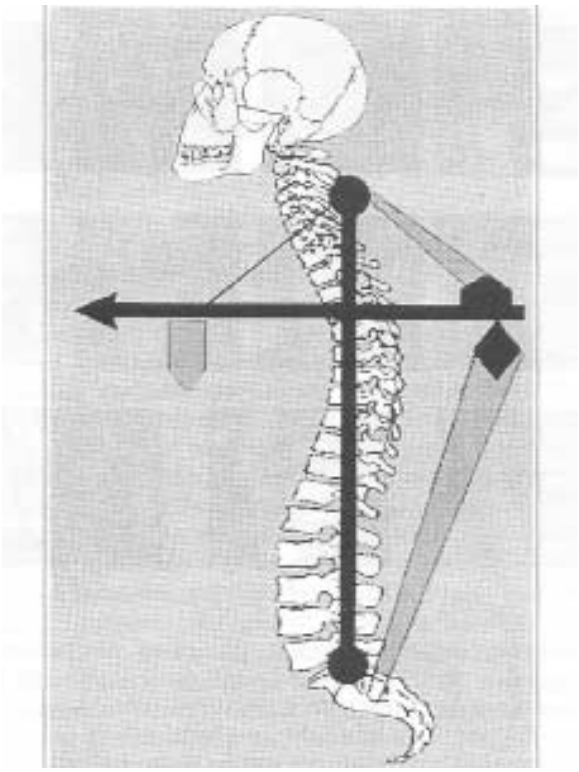


Figure 2: The basic mechanical model of the spine as a crane.

As we can see in this crane model, the amount of deformity, which the construct can withstand, is dependant on the integrity of the posterior tension band. The integrity of the tension band can be reliably assessed only with sagittal MRI's. In our study we saw that even incomplete injuries to the PLC had important mechanical consequences. The basic mechanisms of mechanical failure of the crane can be captured with the A, B, C Type distinction of the Comprehensive Classification (Fig. 3).

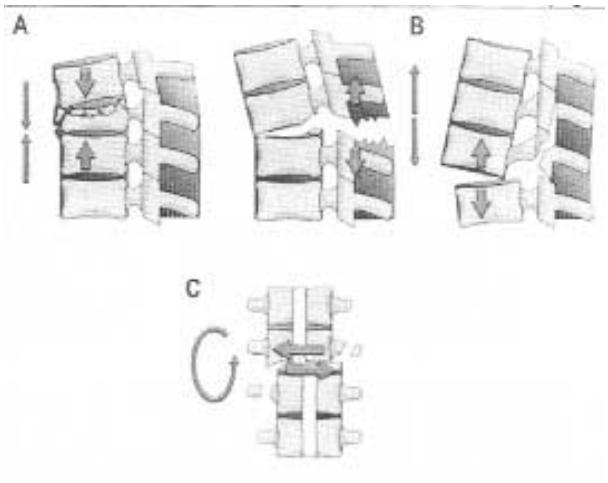
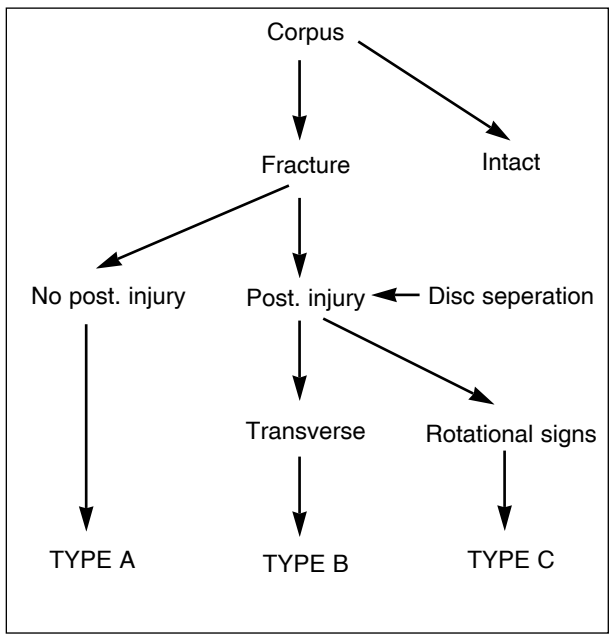


Fig. 3: Type level of the comprehensive classification.

The distinction between common and more stable Type A injuries and the non-A (B and) injuries is difficult and MRI studies are necessary. Even incomplete injuries to the tension band should be seen as indicative of non-A injury. A simple algorithm to make this distinction is as follows:



The next crucial point is the load-sharing capacity of the anterior elements (the tower of the crane). The nature (bony-discoligamentary) and extent (amount of COR, EP and DI involvement) of the injury should be studied to understand the short and long-term consequences. Bony injuries, as long as the deformity is sufficiently corrected and stabilized can be expected to heal rapidly in the young and healthy trauma patients. Discoligamentary lesions may be more unpredictable. However, in the majority of the patients, it seems that insufficient reduction of the endplate deformity more important is for the long-term stability than frank disc degeneration (Oner 1998). Use of our MRI scheme in larger populations may provide more information and help define the residual load-sharing capacity of the anterior elements and help refine the Comprehensive Classification for a better prediction of the long-term stability.

We must not forget that any classification scheme, however sophisticated, can only provide the surgeon with a mental tool to understand the injury and to make an “educated gufess” on the three crucial types of stability:

- Immediate mechanical stability
- Neurologic stability
- Long-term stability.

Any treatment advice based solely on whatever sort of classification is dangerous and should be discouraged. We recommend the use of MRI for all who are interested in contribution to the research of this subject. Further, considering the alarming percentages of PLC injuries missed on conventional radiograms and CT’s, we also think that it is prudent to obtain MRI if one considers non-operative treatment.

(For a more detailed discussion of the subject and complete literature list see the academic thesis of the author that can be accessed via:http://www.library,uu.nl/digiarchief/dip/diss/1885237/inhoud.htm

The entire thesis can be downloaded as a PDF file 2.464 kB)

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