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ORIGINAL ARTICLE

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Classificational problems in ligamentary distraction type vertebral fractures: 30% of all B-type fractures are initially unrecognised

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Abstract The clinical records, operation records, X-rays and CT-scans of 160 operatively treated patients with A-type and B-type spinal fractures were evaluated in a retrospective study. The preoperative diagnosis was compared with the postoperative diagnosis. Analysis of characteristics of patients with A-type fractures (without the unrecognised B-type fractures), initially unrecognised B-type (uB) fractures, and B-type fractures (without the unrecognised B-type fractures) was performed. We analysed the age of the patients, the respective fracture levels, neurologic deficit, anterior wedge angles (AWA), anterior corporal height (ACH), posterior corporal height (PCH), and the percentage of frontal corporal collapse (FCC). The *t*-test was used for statistical analysis. The mean age of patients in each group did not show a significant difference. The group of unrecognised B-fractures had a more caudal fracture level than the recognised B-type fractures. The fracture levels of the A-group and the uB-group patients showed no difference using the *t*-test. The percentage of patients with spinal fractures with neurologic deficit is 16% in the A-type fracture group, 12% in the uB-fracture group and 50% in the B-type group. The preoperative classification of patients in the A-group and in the uB-group showed that patients in the uB-group have more than proportional relatively simple preoperative A-fractures. The AWA and ACH did not show significant differences between the groups. The mean PCH of the uB-group was higher than the PCH of the A-group. No differences were measured between the uB-group and the B-group. The mean percentages of frontal corporal collapse (FCC) did not show a significant difference. Thirty percent of B-type fractures are misdiagnosed when plain X-rays and CT scans with 2D reconstructions are used as the only preoperative diagnostic tools. A large PCH with a normal interspinous distance should raise the suspicion of a B-type lesion. A large AWA does not point to a ligamentary B-type fracture.

Keywords Thoracolumbar spinal fracture · Classification · Ligamentary distraction · Stability · Radiography

Introduction

Judgement about instability of spinal fractures and fracture dislocations is a continuing field of research. Although many authors have pointed out that lesions should be divided into stable and unstable lesions, all structures contribute to stability. All lesions of structures result in a certain instability, but complete instability is rare. An important contribution to stability is given by the posterior dorsal complex, which is formed by the posterior interspinous ligament and the supraspinous ligament. It is one of the merits of the comprehensive classification (CC) that instability is now increasingly considered as a continuous scale. A-type fractures are more stable than B-type fractures, which are, in turn, more stable than C-type lesions. A1 is more stable than A2, etc. [12].

It is difficult to find good criteria for the preoperative diagnosis of a ligamentary B-type lesion, unless there is gross dislocation or a palpable interspinous gap [12]. A preoperative A-type spinal fracture diagnosis was quite often found during operation to be an unrecognised B-type lesion. We analysed our data in order to find, in retrospect, characteristic radiologic qualities of the initially unrecognised B-type fractures. All patient data, including those from patients treated before 1994, were revised according to the CC for this study.

Materials and methods

Between 1988 and 1996 we performed an operative treatment on 160 patients with thoracolumbar A-type or B-type fractures, classified preoperatively. All fractures were treated with instrumental angular reduction, distraction and stabilisation using the Dick internal fixator [6]. Since 1995 we have used the Universal Spine System, Synthes. The procedure was combined with transpedicular cancellous bone grafting of the vertebral body (according to Daniaux) [3, 5] and posterior spondylodesis [3]. After revision of X-rays, CT-scans and operation records we concluded that, during operation, 17 of the 128 A-type fractures appeared to be B-type lesions after exploration of the dorsal ligaments (Fig. 1). A total of 32 B-type lesions were identified preoperatively. Analysis of characteristics of patients with A-type fractures (without the unrecognised B-type fractures), initially unrecognised B-type (uB) fractures, and B-type fractures (without the unrecognised B-type fractures) was performed. We analysed the age of the patients, the respective fracture levels, neurologic deficit, anterior wedge angles (AWA), anterior corporal height (ACH), posterior corporal height (PCH), and the percentage of frontal corporal collapse (FCC) (Fig. 1). The measurements were compared using the *t*-test, and $P<0.005$ was considered significant.

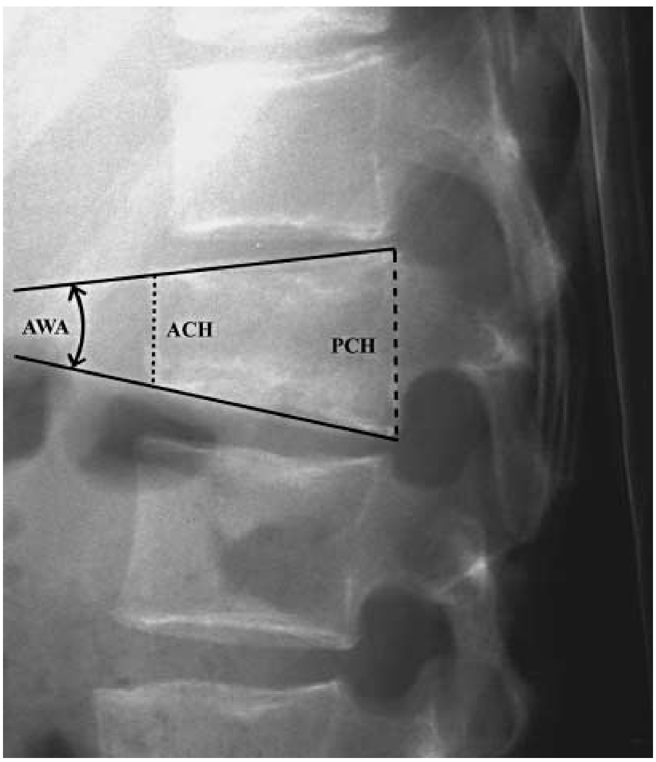

Fig. 1 Measurements in lateral plain X-rays: *AWA* anterior wedge angle, *ACH* anterior corporal height, *PCH* posterior corporal height

Results

The mean age of the patients in each group did not show a significant difference (Table 1). The group of unrecognised B-fractures had a more caudal fracture level than the recognised B-type fractures. The fracture levels of the A-group and uB-group patients were not shown to be significantly different using the *t*-test. The percentage of patients with spinal fractures with neurologic deficit is 16%

Table 1 Age, fracture level and neurologic deficit in A-type, uB-type and B-type fractures. Fracture *level 11* 11th thoracic vertebra, *level 12* 12th thoracic, level 13 1st lumbar vertebra, etc, * Statistical significant difference, $P<0.05$

Fracture type	A	uB	B
Number (*n*)	111	17	32
Age (years)	36.3	32.9	32.0
Fracture level	13.2	13.5*	12.8*
Neurologic deficit (%)	16	12	50

Table 2 Preoperative classification in 111 A-type fractures and 17 unrecognised B-type fractures

	A	uB		A	uB
A1	15	5	A1.1	1	0
			A1.2	13	4
			A1.3	1	1
A2	4	0	A2.1	1	0
			A2.2	0	0
			A2.3	3	0
A3	92	12	A3.1	55	5
			A3.2	21	5
			A3.3	16	2

Table 3 Anterior wedge angle, anterior and posterior corporal height, and frontal corporal collapse in A-fractures, uB-fractures and B-fractures. * Statistical significant difference, $P<0.05$

Fracture type	A	uB	B
AWA (degrees)	17.8	17.5	20.0
ACH (mm)	23.3	25.6	24.3
PCH (mm)	36.9*	40.2*	38.6
FCC (%)	34.2	30.9	29.8

in the A-type fracture group, 12% in the uB-fracture group and 50% in the B-type group. The preoperative classification of patients in the A-group and uB-group is compared in Table 2. Patients in the uB-group have more than proportional relatively simple preoperative A- fractures.

AWA and ACH did not show significant differences between the groups (Table 3). The mean PCH of the uB-group was higher than the PCH of the A-group. No differences were measured between the uB-group and the B-group. The mean percentages of frontal corporal collapse (FCC) did not show a significant difference.

Discussion

One of the problems with comparing different studies in this field is the lack of uniformity in the use of classifications before CC was introduced [12]. Nicoll classified vertebral fractures on an anatomical basis, in four categories: anterior wedge angle, lateral wedge angle, fracture dislocation, and isolated fracture of the neural arch [17]. Holdsworth introduced the mechanism of injury into his classification: stable simple wedge fractures, stable compression or burst fractures, flexion–rotation fractures, instable fracture dislocations (extension type and rotational type)[9]. He stressed the value of palpation of the posterior ligamentary complex, consisting of interspinous and supraspinous ligaments, in order to judge stability.

Chance described the osseous distraction fracture in 1948 and suggested it was a relatively stable fracture that should give a near 100% prognosis [2]. Nowadays, we consider these osseous (and ligamentary) posterior lesions, flexion distraction or B-type lesions as rather unstable [12].

Whitesides introduced the two-column concept: a pressure-resistant ventral column of vertebral bodies and discs, and a posterior column of elements with tensile strength [22]. The role and importance of the structures of the *segment moyen* around the spinal canal and the middle column (ventral to the spinal canal) were described by Roy–Camille and by Denis in the early 1980s, and the three-column concept was widely accepted [4, 22]. Ferguson added the mechanism of injury and gave seven categories [7]. The *load-sharing classification* of McCormack, and the previously mentioned classification of Ferguson, tried to provide a classification on which to base the choice of therapy [7, 13].

The CC 1994 provides a degree of instability as a reflection of a progressive scale of morphological damage, rather than dividing between stable and unstable fractures [12].

Some difficulties have still not been solved, for example: differentiation between A- (compression) type and ligamentary B- (distraction) type vertebral fractures sometimes is difficult, and consideration of the condition of the ligaments is essential. In some cases these dorsal ligaments are evaluable only in an indirect way in plain X-rays, conventional tomographies and CT scans. A (large) gap between the spinous processes indicates rupture of the interspinous and supraspinous ligament. Osseous distraction lesions, such as the Chance-type fracture, can be recognised more easily in plain lateral X-rays [2].

About 30% of B-type vertebral fractures are misinterpreted and considered to be A-type fractures, according to the CC [12], since ligamentary lesions are not recognised in plain X-rays and CT-scans (Figs 2 and 3). This phe-

Fig. 2 Lateral X-ray of a patient with an initially unrecognised B-type fracture

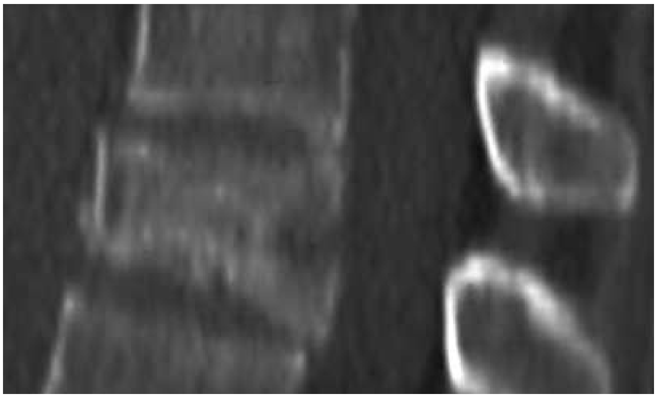

Fig. 3 Sagittal 2D-reconstruction of a CT scan of a patient with an initially unrecognised B-type fracture (same patient as in Fig. 2)

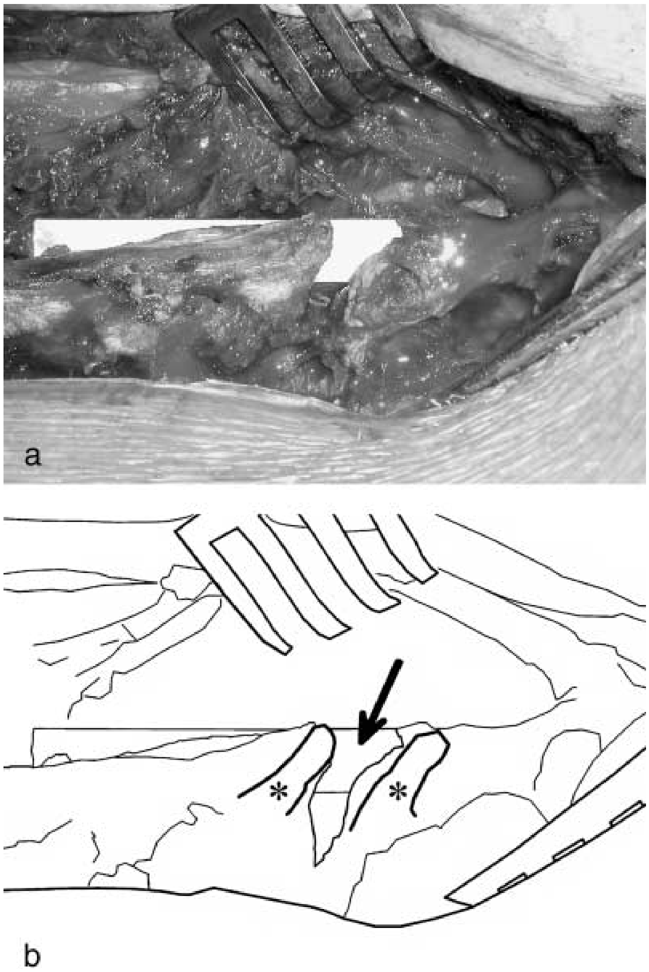

Fig. 4 **a** Peroperative photograph of the ruptured interspinous ligament, as found during dorsal exploration. The left side is cranial, the right side is caudal. **b** Diagram showing the same patient: *arrow* ligamentary tear, * spinal process

nomenon leads to the intra-operative correction of the preoperatively type-A classified fractures of the thoracolumbar vertebral column in ligamentary distraction (B1.2) type fractures (Fig. 4a, b).

The difference in PCH between A-lesions and uB-lesions might be an explanation for the existence of dorsal ligamentary lesions in the uB-group. The (intact or relatively high) posterior wall in the uB-lesions acts as a fulcrum. In further traumatic flexion and ventral compression the dorsal ligament stretches until it tears. In cases of spontaneous reduction of the dorsal structures the lesion can easily be misinterpreted. The PCH in B-lesions, however, does not differ from either A-lesions or uB-lesions. This means that a typical A-type fracture with a rather high PCH should give rise to the suspicion that this fracture might be a less stable B-type fracture.

An AWA of more than 16–20° in an A-type fracture has been suggested to be a type B-lesion[1]. In vitro studies of flexion–distraction injuries of the lumbar spine, and the effect on stability, showed the first sign of permanent deformation at a flexion of 15.8°. Total disrupture occurred at 19.6° [14, 15]. We could not confirm this kind of discrimination between A-type, uB-type, and B-type lesions (Table 3).

Although uB-fractures are more caudal than recognised B-fractures, the difference is too small to be of clinical relevance. The difference regarding neurologic deficit suggests that patients without neurologic deficit have a larger chance of being misdiagnosed and, possibly, undertreated. Combined with the observed preoperative classifications, this is an even stronger possibility in rather simple fractures (A1.2 and A1.3) without neurologic deficit and in more caudal lesions (L2, L3 and L4). Determination of the distance between the spinous processes is helpful, unless reduction of the fracture, fracture dislocation, or ligamentary distraction has occurred spontaneously or as a result of repositioning the patient during transport or diagnostics. Measuring differences between the interspinous distances on anteroposterior radiographs will therefore probably be of limited value. However, a difference in interspinous distance exceeding 7 mm should give rise to the suspicion of a ligamentary distraction lesion [16].

Physical examination can reveal a palpable interruption of the chain of spinous processes and dorsal interspinal ligaments [9]. MRI, as well as sonographic investigation, can provide extra information about the integrity of ligaments [8, 10, 11, 21]. The accuracy of MRI (fat-suppressed T2-weighted sagittal sequence) in detecting interspinous ligament injuries is 97%. The positive predictive value is 96.7% and the negative predictive value 100%. In contrast, the same study neither revealed a relation between the findings on palpation and the operative findings, nor between plain radiographs (interspinous gap) and the operative findings [10]. In the study of Williams et al., instability of spinal fractures was diagnosed in 50% of the fractures on plain radiograph review. MRI instability was diagnosed in 73% [23]. In some of these cases there was only indirect evidence of posterior column damage on MRI, for example haemorrhage, but no definable gap in the interspinous ligament. In these patients stretched and *functionless* ligaments were found at operation [23]. An MRI-investigation *instead of* a preoperative CT scan might also be considered [10]. MRI can be helpful in the evaluation of the status of the posterior longitudinal ligament in decision-making about the treatment of individual patients, when posterior instrumentation is considered. The continuity of the interspinous ligaments is of special importance when anterior stabilisation is considered [21]. Öner proposed a preliminary classification scheme of the observed status of the respective ligamentary, disc and osseous structures in three or four categories each. In this way the degree of instability of the anterior longitudinal ligament, posterior longitudinal ligament, posterior longitudinal complex, cranial endplate, caudal endplate, disc, and the vertebral body respectively is registered [19]. MRI can also be used to evaluate the postoperative condition of soft tissue and bone [18, 20]. When only a CT scan is performed preoperatively, operative treatment with dorsal exploration eventually shows the definite condition of the dorsal ligaments. In conservative treatment, under-treatment may occur in unrecognised B-type fractures (Table 2). In future classifications, or modifications to the CC, a way of visualisation of the posterior ligaments should be applied.

Conclusions

Thirty percent of B-type fractures are misdiagnosed when plain X-rays and CT scans with 2D reconstructions are used as the only preoperative diagnostic tools. A large PCH with a normal interspinous distance should give rise to the suspicion of a B-type lesion. A large AWA does not point to a ligamentary B-type fracture.

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