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ORIGINAL ARTICLE

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Unstable vertebral fractures in the lower third of the spine treated with closed reduction and transpedicular posterior fixation: a retrospective analysis of 82 fractures in 78 patients

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Abstract Seventy-eight patients were treated with closed reduction and transpedicular fixation for 82 spine fractures. The fractures were localised in the lower third of the spine and were all, according to the Denis classification, considered unstable. Eighteen patients had neurological deficiencies. One patient with a fracture in T11 was completely paraplegic, four patients had a cauda equina syndrome while the rest had radicular symptoms only. Primary reconstruction of the vertebral height and the physiological curves of the spine was satisfactorily obtained. An improvement in the neurological symptoms was observed in all patients with fractures distal to the spinal cord, while the patient with the dislocated fracture of T11 remained completely paraplegic during the follow-up. The complication rate of the transpedicular fixation method used reported by other authors could not be confirmed in our material. Iatrogenic neurological damage was not observed. A partial loss in the correction of the traumatic kyphosis was observed after removal of the implant in 11 patients.

Key words Thoracolumbar spine · Unstable lesion · Transpedicular fixation

Introduction

Disability due to neural lesions or deformations of the spine may be the end result of a fractured vertebra [4, 5, 10, 11, 13, 17, 21, 24]. While indications for early reduction and stabilisation of unstable fractures in the thoracic part of the spine remain controversial, this procedure is unquestionably valid in unstable fractures of the lower spine [10–12, 17].

Transpedicular posterior fixation techniques have improved the possibility of reduction and stabilisation of the injured segments without involving non-injured parts of the spine [2, 10, 11, 24, 25].

In our department we have used closed reduction and posterior transpedicular fixation in the treatment of unstable fractures of the lower third of the spine since 1988. During the first 5 years we used the "internal fixator" first described by Walter Dick [10, 11]. Since 1994 we have used the third generation of Dick's "internal fixator", the Universal Spine System (USS, AO/ASIF). This report is a retrospective analysis of patients with unstable fractures of the lower third of the spine treated with this method from 1988 to 1994.

Materials and methods

Patients

Seventy-eight patients, 47 men and 31 women, with a median age of 27 (14–59) years were treated for 82 unstable fractures. Fracture localisation was: 1 fracture in T10, 5 in T11, 6 in T12, 22 in L1, 17 in L2, 12 in L3, 12 in L4 and 7 fractures in L5 (Fig. 1). Four patients had unstable fractures in two vertebrae (1 × T12 and L4, 1 × L3 and L4 and 2 × L1 and L4). Twenty-two patients were polytraumatised, with an Injury Severity Score (ISS) exceeding 16 [1]. Eighteen patients had additional lesions, but an ISS less than 16. The main additional lesions were fractures of the long bones, calcaneal fractures, maxillofacial fractures and pelvic fractures.

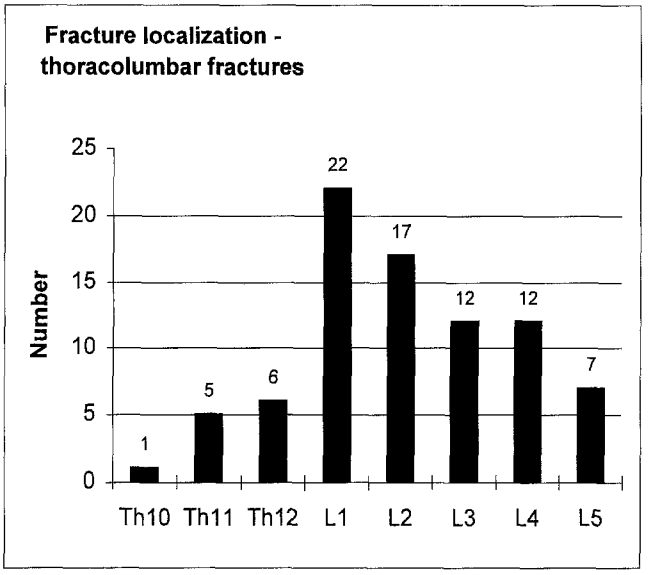

Fig. 1 Fracture localisation in 82 fractures

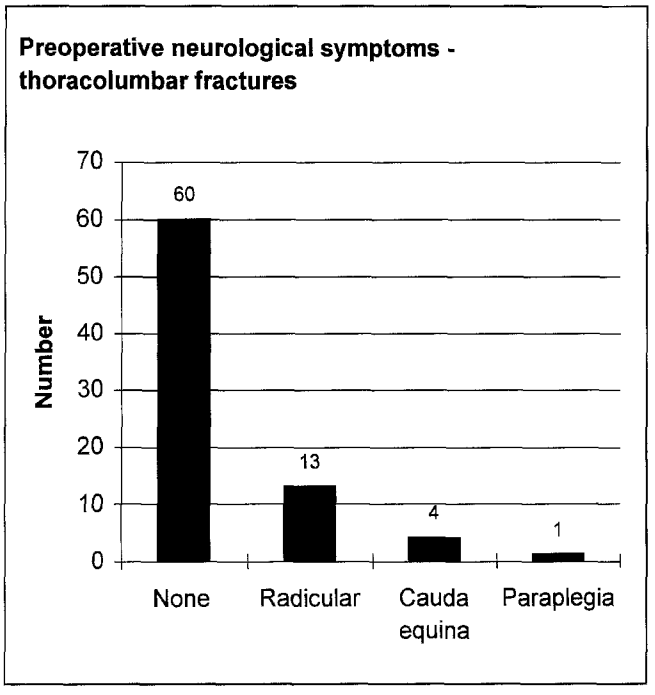

Fig. 2 Preoperative neurological symptoms in 18 patients

Thirty-eight patients had no lesions other than the vertebral fracture(s).

Eighteen patients had marked neurological deficiency preoperatively: 1 patient was completely paraplegic (T11), 4 patients had a cauda equina syndrome and 13 patients had radicular symptoms (Fig. 2).

Thirty-eight patients had suffered a traffic accident; 18 patients were injured during sports activities, while falls from a variety of heights during occupational or recreational activities caused the lesion in the rest of the 78 patients. Fifty-five patients were employed at the time of their injury, while 23 patients were students or unemployed. Median time from injury to operation was 2 (0–11) days.

Methods

All patients were evaluated preoperatively and postoperatively by conventional radiography and CT. The criteria for instability defined by Denis [8] were used. Asymmetric pedicle distance on the frontal radiographic view and fracture of one or both pedicles on CT scan, posterior vertebral dislocation of the fractured vertebra on the side projection as well as more than 50% anterior height reduction of the fractured vertebra were criteria used to decide on operative treatment (the original anterior height of the fractured vertebra was calculated as the arithmetic mean of the anterior height of the vertebrae cranial and caudal to the fractured vertebra). A further absolute criterion for operative treatment was spinal canal narrowing (digitally measured by cross-section on CT) of more than 40%.

The patients were placed in prone position. The lamina and transverse processes of the vertebral body cranial and caudal to the fractured vertebra were prepared by the use of a midline incision. Anatomic landmarks in determining the correct position of the transpedicular screws were the facet joints and the transverse processes. An image intensifier placed with the C-arm beneath the operating table allowed fluoroscopy in different planes. Fluoroscopy was used to identify the fractured vertebra and the pedicular and intravertebral position of the screws, and to confirm the reduction and restoration of the height and shape of the fractured vertebra. Only occasionally, and mainly in the lower thoracic spine, fluoroscopy was used in the frontal plane to confirm the position of the screws. At the introduction of the method we controlled the correct position by insertion of Kirshner wires into the pedicle, and fluoroscopy in different planes. The Kirshner wires were replaced by Schanz screws after predrilling of the pedicles with a 3.5-mm drill bit. Today we introduce the screws directly after having opened the pedicle with an awl, and do not use Kirshner wires. Through manipulation of the transpedicular screws, reconstruction of the physiological spine configuration was achieved after having placed the paravertebral rods and the fixation clamps. After correction of the spine configuration the clamps were tightened on the pedicle screws. Restoration of the height of the fractured vertebra and the anterior part of the spinal canal was then obtained by distraction on the paravertebral rods. The rods guaranteed stability in the sagittal plane. When instability in the frontal plane was present, or suspected, a transverse rod fixed to the paravertebral rods with clamps (in the early operated cases a transverse cerclage wiring) was added.

In the patients with two fractures of the lumbar spine, segmental transpedicular fixation was performed in the two with two uninjured vertebrae between the fractured vertebrae, while in the patient with L3 and L4 fracture both fractured vertebrae were reduced and stabilised with transpedicular fixation from L2 to L5.

In 63 fractures a transpedicular bone graft according to Daniaux [7] was performed. Autologous cancellous bone was harvested from the left posterior crest by the use of an acetabular reamer as described by Dick [9]. Laminectomy was performed in one patient only, while a partial laminectomy was performed in two patients. In four patients a postero-lateral fusion by bone graft was added, because of a mainly ligamentous lesion. The majority of the polytraumatised patients had their major lesions treated by surgery during one anaesthesia only.

In all patients with neurological deficiency, treatment with high-dosage corticosteroids as recommended by Bracken et al. [3] was started on admittance to the hospital.

Postoperative conventional radiography documented the reduction result, and a postoperative CT scan of the fractured vertebra confirmed the position of the pedicular screws and the restoration of the spinal canal. The postoperative correction of the traumatic

deformity of the spine in the sagittal plane was evaluated by measuring the kyphotic angle between the end-plates of the adjacent vertebrae in conventional radiograms. Radiological documentation after implant removal was obtained with the patient in standing position.

All patients were mobilised with a three-point brace on the 2nd or 3rd day after surgery or as soon as was permitted by the other lesions.

The patients were all followed clinically at 6 and 12 weeks as well as 1 year after surgery. In all patients who did not undergo postero-lateral fusion, the implant was recommended to be removed 12–18 months after surgery. Median observation time was 25 (5–48) months.

Results

Median stay in a recovery or intensive care unit was 21 (10–40) days. 54 patients were discharged for further rehabilitation to a rehabilitation centre, while 24 patients were dismissed from hospital to their homes for further rehabilitation by ambulatoric physiotherapy.

Eight general complications occurred. Three patients suffered local superficial infections and one had a deep wound infection. The superficial infections were treated with antibiotics after cultures had been obtained. In the patient with deep infection, removal of the implant and the use of gentamycin beads was carried out 6 months after the index operation. The further course of this patient was uneventful and the early implant removal did not influence the final result in this polytraumatised patient, who had the fracture located in her fifth lumbar vertebra. In addition, three patients were treated with antibiotics due to pneumonia in the early postoperative period, while one patient had to be treated with heparin and oral anticoagulation medication because of a thromboembolic complication.

No neurological complications were associated with the operations. Fatigue fracture of one or more screws was observed at late controls, without having an influence on the final result, in six patients. Pedicular, but extracorporal, position of the screws was observed in three patients at the early postoperative CT controls. This did not influence the stability of the bone/implant construct nor the final result in any of the patients. The median anterior height reduction of the fractured vertebra at the final follow-up was 10% (0–20%) in comparison to the preoperative anterior height reduction of 30% (0–90%). A reduction of the preoperative spinal canal narrowing from median 35% (0–55%) to 11% (0–20%) postoperatively was recorded, as measured digitally on cross-sectional CT images. A primary correction of the traumatic kyphotic deformation was obtained in all patients. A partial loss of correction of median 5° (0–18°) was registered in 54 patients after removal of the implant, at a median of 13 (5–16) months postoperatively. This loss of correction did not correlate with loss of vertebral height, but was mainly due to a change in the intervertebral disc cranial to the fractured vertebra. In some patients with fractured screws,

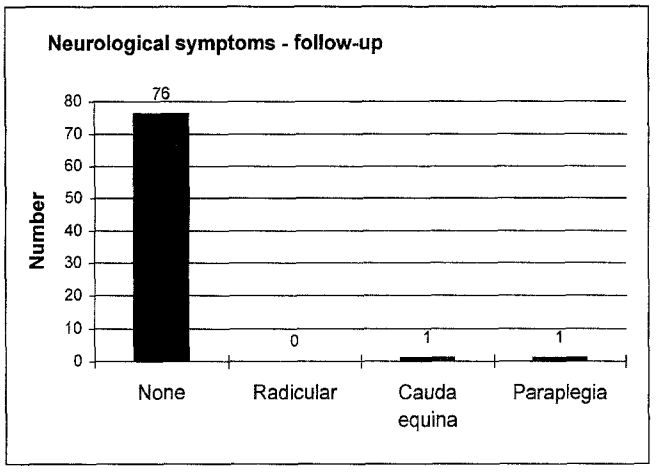

Fig. 3 Neurological symptoms at the last follow-up

the implant was removed only partially. No screws fractured before 12 weeks after surgery and implant failure did not influence the final outcome in any of the reported patients.

All 13 patients with fractures of the lumbar spine and radicular neurological symptoms improved their neurological status during the follow-up. Three of four patients with a cauda equina syndrome regained normal bladder and bowel function, but showed some sensoric and motoric neurological disturbance at the final follow-up. One patient with cauda equina syndrome still had some dysfunction of his bladder.

The patient with complete paraplegia caused by a dislocated fracture of the 11th thoracic vertebra showed only a slight improvement of her neurological status (sensibility) at the final follow-up 14 months after injury (Fig. 3). She was still dependent on a wheelchair, but had started training with walking aids (crutches and locking braces). Eight patients had changed their occupational status after the injury and 12 patients had some kind of working disability, qualifying for a partial disability compensation from the national health insurance.

Twenty-one patients are still in ambulatoric control due to other reasons than their fractured spine.

To illustrate the results, Figs. 4–9 present the plain film and CT series of a 20-year-old male patient who suffered an unstable fracture of his second lumbar vertebra.

Discussion

An injury of the spine may include an injury of the neural structures in the spinal canal. This may be an acute injury to the neural elements or a potential injury caused by the persistent instability of the vertebral column. The criteria for instability in spine fractures are discussed in the literature [8, 9, 17–19, 24]. Injuries with neural deficiency and obvious mechanical instability have to be differentiated

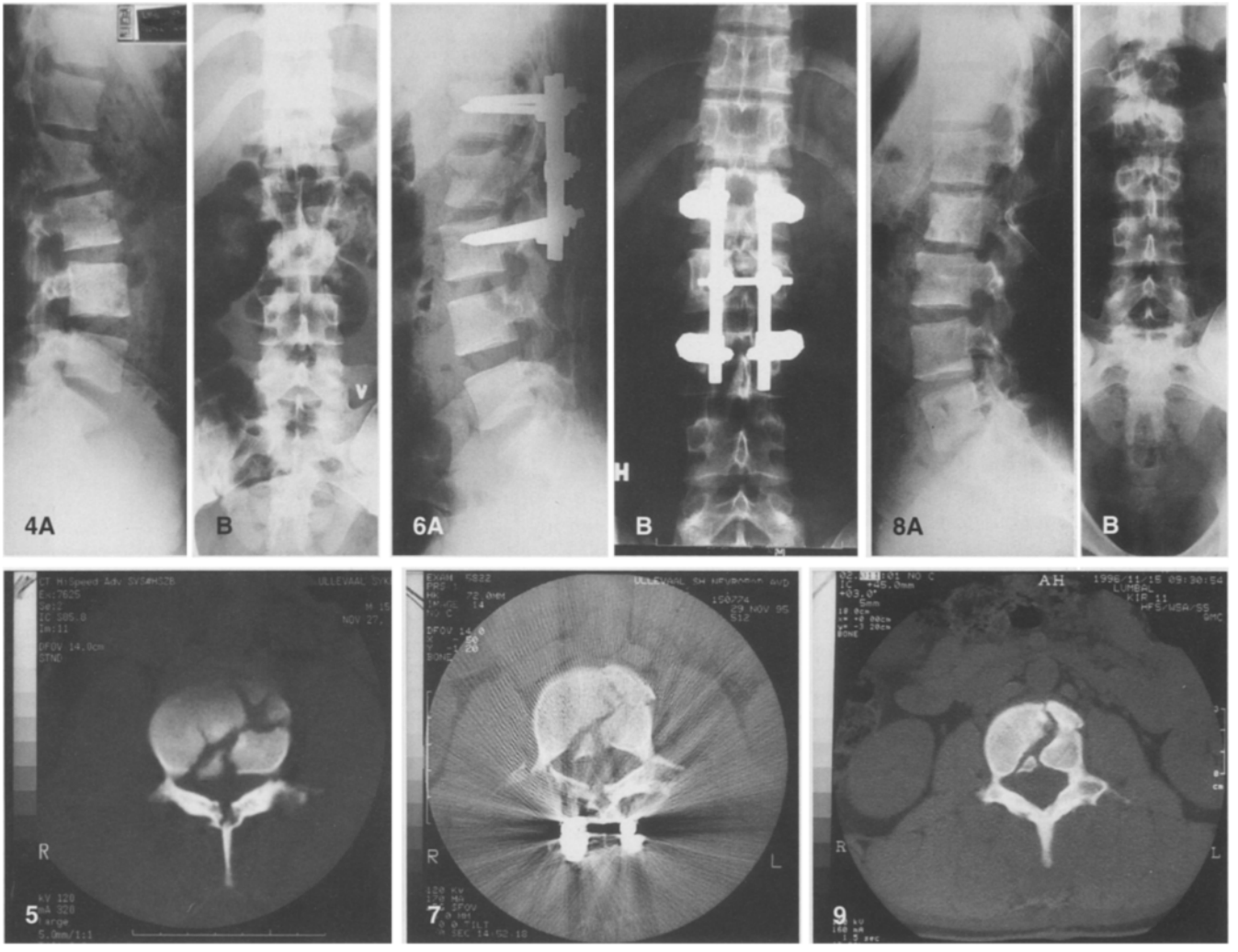

Fig. 4 A, B Preoperative plain radiograph of an unstable fracture in L2 in a 20-year-old man who suffered a climbing accident. There was no neurological deficiency

Fig. 5 Preoperative CT scan of the fractured vertebra showing the pedicle fracture, the fragmentation of the vertebral body and the intraspinal fragment

Fig. 6 A, B Postoperative plain radiograph after closed reduction and transpedicular fixation. No bone grafting was carried out

Fig. 7 Postoperative CT scan of the reduced vertebra showing reduction of the fragments and widening of the spinal canal

Fig. 8 A, B X-ray control 1 year after the accident, following metal removal, showing restored anatomy and configuration of the spine

Fig. 9 CT scan 1 year after the accident showing consolidated pedicle and restored spinal canal

from injuries with no, or no imminent, neural lesion, and from instabilities causing progressive deformation of the spine. To classify the spinal injury we have used the three-column spine model and its significance in the classification as described by Denis in 1983 [8]. A spinal injury is defined as unstable when, during mobilisation without any stabilisation (by external or internal means), increasing deformity is to be expected or when a neurological deficiency is imminent or immediately apparent. Furthermore, a reduction of the anterior height of the fractured vertebra exceeding 50% of the estimated anterior height as well as major reduction of the spinal canal due to vertebral fragment protrusion, was considered an indication for operative treatment even if no neurological symptoms were present. Acute injury of the spinal cord is followed by post-traumatic oedema causing microvascular changes of the cord. Haemorrhage from the fracture site into the spinal canal may compromise the neural structures further. Experience during the last decades in the treatment of dislocated or unstable fractures of the long bones and the pelvis has proved that the best way to prevent this post-traumatic oedema and haemorrhage is to reduce and stabilise the fracture [20]. Even if the value of primary operative treatment in spinal cord injury remains under discussion, reduction and stabilisation of the unstable spine

is generally accepted as the treatment of choice [9–12, 16].

The value of CT in the classification of thoracolumbar fractures is unquestionable. CT scans of the fractured area of the spine are of great value in deciding whether surgery is indicated [19]. Three-dimensional reconstruction of the spine by data tomography is now possible [6]. We have no experience with this imaging technique in spine injuries. The information this additional diagnostic tool gives may, however, change the indications for surgery of spine injuries in the future. The AO/ASIF classification of spine injuries gives information about the pathomorphology, severity and prognosis of the lesion [18]. Treatment recommendations are further information provided by this classification. In the future we intend to evaluate this classification model in the treatment of spine fractures.

Direct surgical approach to the neural structures becomes unnecessary. Restoration of the vertebral body by distraction and by restoration of the physiological lordosis of the spine decompresses the spinal canal by acting where the compression takes place, namely anteriorly, and not, as by laminectomy, posteriorly [9–11, 14, 15, 21, 22]. Early treatment is mandatory when closed reduction techniques are chosen to restore the anatomy of the fractured spine. In the series of patients reported in this study, the median time between injury and surgery was 2 (0–11) days. This may explain the good results achieved concerning reconstruction of the anatomy.

To confirm the restoration of the spinal canal, we performed intraoperative myelography after reduction and fixation of the fractured vertebra in the first patients treated by the method described. The fact that the restoration of anatomy regularly restored the spinal canal led us to abandon intraoperative myelography as a routine procedure.

Our experience with the method described has, in the last 3 years, led to a less strict use of a brace in the postoperative mobilisation period. Today we use the brace only as a "reminder" of the injury in patients with high activity levels, to prevent strenuous activities.

Partial loss of correction of the kyphosis after implant removal has been observed. This loss of correction is not correlated with loss of vertebral height after implant removal, but mainly with the damage of the intervertebral disc cranial to the fractured vertebra. As in the majority of the fractures ($n = 63$), and in all fractures with severe reduction of the anterior vertebral height, we applied a corporal bone graft, it is not possible for us to state whether bone grafting did prevent loss of vertebral height or not. Transpedicular bone grafting of the fractured vertebra is, however, based on the same rationale as bone grafting of impacted fractures in intra-articular fractures of weight-bearing metaphyseal bones, as in the tibia condyle or in the pilon fracture of the distal tibia. We do not know whether this rationale is valid in the fractured vertebra. A randomised study will be designed to examine this. The clinical value of the loss of correction of the traumatic kyphosis and the damage to the intervertebral disc cranial to the fractured vertebra are other factors to be addressed in the long-term follow-up.

The results in the series reported show that primary restoration of the vertebral body and the spine configuration may regularly be achieved by closed reduction and transpedicular fixation in fractures of the lower third of the spine. The stability of the "internal fixator" we used allows early mobilisation without extensive additional devices. Posterolateral or anterior approaches with anterior decompression by vertebrectomy have not been necessary in any of the patients reported.

The study shows no correlation between loss of kyphotic correction, disc collapse and patients' complaints at follow-up so far. In our opinion, the loss of kyphotic correction we have observed does not justify a change of procedure in the treatment of patients with unstable fractures in the lower third of the spine. Our results do not confirm the statement by Speth et al. [23] regarding the complication rate and loss of vertebral body height in transpedicular fixation of vertebral fractures.

Metal removal has been performed in 54 of the 78 patients. Implant removal was recommended 12–16 months after surgery in all patients where no posterolateral fusion had been performed. The "remobilisation" of the immobilised segments seems rational, and fatigue fracture(s) of the pedicular screws have to be anticipated during mobilisation if no fusion procedure is carried out.

In contrast to other reported cases, the patients reported in this article represent a young population [4, 9, 17]. This may be due to the fact that the majority of the patients had suffered traffic or sports accidents. Furthermore, Ullevål Hospital is a university hospital receiving polytraumatised patients referred from the region. Forty of the 78 reported patients were polytraumatised.

Conclusion

Closed reduction and transpedicular stabilisation of unstable fractures in the lower third of the spine has become a routine operation in our department. The operation is performed as an emergency operation by an orthopaedic consultant, and thus handled like other unstable fractures in the locomotor system. The complication rate is low, the hospitalisation time short and the final outcome satisfactory concerning morbidity and disability.

References

1. Baker SP, O'Neil B, Handonget W, Long WB (1974) The injury severity score: a method for describing patients with multiple injuries. J Trauma 14: 187–196
2. Bjerkreim I, Strømsøe K, Lange JE (1988) Transpedicular fixation for instability of the lower thoracic and lumbar spine (in Norwegian). Tidskr Nor Lægeforen 108:2471–2473
3. Bracken MB, Shepard MJ, Collins WF, Holford TR, Young W, Baskin D, Eisenberg HM, Flamm E, Leo-Summer L, Maroon J, Marshall LF, Perot PL, Piepmeier J, Sonntag VKH, Wagner FC, Wilberger JE, Winn R (1990) A randomized controlled trial of methylprednisolone or naloxene in the treatment of acute spinal-cord injury. N Engl J Med 322:1405–1411
4. Böhler J (1974) Verletzungen der Wirbelsäule. Z Orthop Ihre Grenzgeb 112:894–896
5. Böhler L (1932) Die Behandlung der Wirbelbrüche. Arch Klin Chir 172: 842–848
6. Böhmer G, Hierholzer G (1990) Dreidimensionale Rekonstruktion computertomographischer Wirbelsäulenschichtaufnahmen. Oper J 2:50–53
7. Daniaux H (1986) Transpedikuläre Reposition and Spongiosaplastik bei Wirbelkörperbrüche der unteren Brust und der Lendewirbelsäule. Unfallchirurgie 89:197–213
8. Denis F (1983) The three column spine and its significance in the classification of acute thoracolumbar spinal injuries. Spine 8:817–824
9. Dick W (1984) Innere Fixation von Brust und Lendenwirbelfrakturen. Hans Huber, Bern, p 125
10. Dick W (1987) The fixateur interne as a versatile implant for spine surgery. Spine 12:882–900
11. Dick W, Wørsdørfer D, Magerl F (1985) Mechanical properties of a new device for internal fixation of spine fractures: the "fixateur interne". In: Perren SM, Schneider EV (eds) Developments in biomechanics, vol 2, pp 501–506
12. Frankl HL, Hancock DFO, Hyslop G, Melzak J, Michaelis S, Ungar H, Vernon JDS, Walsh JJ (1969) The value of postural reduction in the initial management of closed injuries of the spine with paraplegia and tetraplegia. Paraplegia 7:179–186
13. Härkonen M, Kataja M, Lepistö P (1979) Fractures of the thoracic spine. Arch Orthop Trauma Surg 94:179–180
14. Kuner EH, Kuner A, Schlickewei W, Wimmer B (1992) Die Bedeutung der Ligamentotaxis für die Fixateur Interne-Osteosynthese bei Frakturen der Brust und Lendenwirbelsäule. Chirurg 63:50–55
15. Kuner EH, Schlickewei W, Hauser A, Kuner A (1996) Zur Wiederherstellung der lichten Weite des Spinalkanals durch Fixateur-Interne Instrumentation und Remodeling. Chirurg 67:531–538
16. Lindsey RW, Dick W (1991) The fixateur interne in the reduction and stabilization of thoracolumbar spine fractures with neurologic deficit. Spine 16: 140–145
17. Magerl F (1982) Stabilisierung der unteren Brust und der Lendenwirbelsäule mit dem Fixateur externe. Acta Chir Aust [Suppl] 43:78–80
18. Magerl F, Aebi M, Gertzbein SD, Harms JD, Nazarian S (1994) A comprehensive classification of thoracic and lumbar injuries. Eur Spine J 3: 184–201
19. McAffee PA, Yuan AH, Fredrickson BE, Lubicky JP (1983) The value of computed tomography in thoracolumbar fractures. J Bone Joint Surg [Am] 65:461–473
20. Perren SM (1991) Basic aspects of internal fixation. In: Müller ME, Allgöwer M, Schneider R, Willenegger H (eds) Manual of internal fixation. Springer, Berlin Heidelberg New York, pp 1–112
21. Roy-Camille R (1980) Management of fresh fractures of the thoracic and lumbar spine. Hefte Unfallheilkd 148: 18–19
22. Sasso RC, Cotler HB (1993) Posterior stabilization and fusion for unstable fractures and fracture-dislocations of the thoracic and lumbar spine. Spine 18:45–60
23. Speth MGJM, Oner CF, Kadic MAC, de Klerk LWL, Verbout AJ (1994) Recurrent kyphosis after posterior stabilization of thoracolumbar fractures. 24 cases treated with a Dick internal fixator followed for 1.5–4 years. Acta Orthop Scand 66:406–410
24. Strömsöe K (1992) Unstable back injuries: guidelines for management (in Norwegian). Tidskr Nor Lægeforen 112:1282–1286
25. Whitesides TE (1976) On the management of unstable fractures of the thoracolumbar spine: rationale for the use of anterior decompression and posterior stabilisation. Spine 1:39–45