Thoracolumbar spinal fractures
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Chapter 7

General discussion, recent, present and future developments

Introduction

In Chapter 1 (General introduction) we gave an overview of the questions that we answered in chapter 2 to chapter 6. The most important answers and the conclusions that were drawn from these answers will be discussed in this chapter because they imply important consequences for future management of spinal fractures.

Conclusions and consequences

At least 30% of the B-type lesions are unrecognised without operation [20]. These are interpreted as relative simple A-type fractures in stead. The result of this misinterpretation is a higher chance for relative undertreatment. Research in the field of spinal fractures demands a good classification, but in clinical practise it is important as well. Although we have been using the comprehensive classification since 1994 [21], we often feel the need for better evaluation of the soft tissues like ligaments and discs, so that those lesions can be incorporated in classifying the fracture complex. In our view radiographs and CT-scans with reconstructions no longer are sufficient. MRI seems to be the most suitable diagnostic instrument to supply the missing data, but MRI images registered shortly after the accident are difficult to interpret, because it takes some time before the amount of water in the tissues changes (oedema). We should find new ways to evaluate the MRI findings in the immediate posttraumatic period to improve decision making in the process of diagnostics and treatment. Although some important steps have been made [25-27], further MRI studies will have to be performed. For example endplate...
comminution and posterior ligament complex lesions as recognised in MRI predict recurrence of the kyphotic deformity [25].

In the near future new generation MRI can probably completely take over the position of CT-scan in spinal fracture diagnostics. It will diminish roentgen exposure, but it will also have major consequences on logistics, because MRI generally is less available than CT, changes in the MRI set up can be necessary before the diagnostic procedure can be performed, and after early procedures a repeated procedure might be necessary to draw definitive conclusions about the condition of the ligaments and discs.

After completing the radiological result studies in this thesis we can confirm certain aspects suggested in the literature, like the loss of the reduced regional angle in the course of follow up. We could clearly show that this is a gradual occurring phenomenon, predominantly caused by collapse of the intervertebral space after implant removal, and not influenced by (major) loss of anterior wedge angle of the reduced vertebral body [19]. We should realize that early studies concerning dorsal instrumentation using the Dick internal fixator revealed excellent results [1;24], just because of short follow up. The longer the follow up, the more loss of reduction of regional angle [12;13;19;29]. We showed that reduction of the vertebral body (AWA) combined with transpedicular cancellous bone grafting is effective and lasting, in contrast with other studies [12;14]. This might be the effect of double-sided cancellous bone graft.

In the aforementioned studies the cancellous bone graft was intended to act as an interbody fusion technique, after removing the disc the disc space was filled with cancellous bone as well as the reduced vertebral body. CT-scans revealed that the interbody fusion was insufficient [13].

Unfortunately detailed comparison of outcome in different studies in dorsal instrumentation is not possible, because many variations of the technique, the rehabilitation, the follow up, and the way of evaluation are used in different studies. We never performed direct decompression by laminectomy or corporectomy, but others see this as a standard procedure in case of neurological deficit.

To evaluate the effectiveness of the operative treatment with indirect reposition and fixation with an internal fixator, unilateral transpedicular bone grafting and dorsal spondylodesis at the disc levels with endplate lesions compared to conservative treatment (six weeks of rest in supine position followed by mobilisation of the patient with a inclination corset) we designed a randomised trial. In this trial patients with A-type fractures without neurological deficit are included. In this trial not only radiological parameters are compared, but also
functional aspects, measured by Roland Morris Disability Questionnaire and VAS Spine Score, as well as cost-effectiveness, are evaluated.

The spinal canal is reduced partly as an effect of ligamentotaxis during operation. After the immediate postoperative period a further spontaneous remodelling occurs, not caused by ligamentotaxis. This study confirms earlier results in CT-scans in the literature [6;7;10;11;18;28;32]. We showed that the phenomenon can also be visualized in plain lateral radiographs, although not as accurate as in CT-scans. The remodelling process reveals a gradual clearance of the spinal canal in two years in 97% of the patients. Remodelling was used as a plea against operative treatment [11], and it was one of the arguments against direct or open surgical decompression of the spinal canal as well [3;28]. An explanation for the spontaneous remodelling could not be found. Spinal fluid pressure changes, caused by respiration are suggested to be the drive of this process of remodelling [28]. Bone remodelling, including growth and bone formation, however, are the results of all functional influences, so one can imagine that in normal weight bearing the best form and structure of the spinal column includes a more or less normal spinal canal. More research is needed to clear this subject.

Two years after the operative treatment and more than a year after implant removal the ROM of the segment of the spondylodesis equals zero. It is concluded that the dorsal spondylodesis is effective [19]. The other temporarily bridged segment regains only about 50% of the normal ROM. The ROM of the segment above the internal fixator diminishes to 50% as well (compared to normal values). So there is considerable cumulative loss of motion. Regain of ROM after trauma, operation and partial immobilization is a dynamic process. In the future we hope to study ROM as one of the functional aspects of the back in more frequent measurements to clear the dynamic aspects without flexion and extension radiographs (Fig.1).

A series of tests concerning multiple aspects of functional outcome revealed that most patients with spinal fractures without neurological deficit have regained their abilities after three to eight years. The series of tests revealed restrictions in body function and structure (AWA, RA, functional capacity, arm, trunk and leg lifting tests), restrictions in activities (RMDQ and VAS Spine Score) and restrictions in participation in daily life (SF36 and return to work status). We could only study a small group of patients. Though we can state that the results are remarkable. Most of the patients have returned to their previous work. In some of the patients some kind of adaptation was necessary to permit them to perform their work. In the functional tests patients have poor scores in the leg lifting test. Therefore muscle training of the lower extremities should be encouraged in the rehabilitation period.
and the effect of this training has to be evaluated. Lifting tests and questionnaires provide many data about the subjective functional status of the individual patient: we recommend a regular use of at least the RMDQ or VAS Spine Score in the follow up in the clinical setting. The VAS Spine Score seems to reflect this status more precisely than the RMDQ, but further evaluation of both methods in spinal fracture treatment is necessary. Only few studies supply data of RMDQ [17;31] in spinal fracture patients, as it is designed to evaluate low back pain treatment. Even less studies supply normal data in the recently developed VAS Spine Score [16]. Whether we compare our data to low back pain studies or spinal fracture studies, the results are very much in favour of our series.

Recent research, ongoing studies and new developments

New minimal invasive techniques will be introduced in order to improve the operative treatment of spinal fractures. For example, in selected cases thoracoscopic anterior instrumentation in thoracic spinal fractures (T6-T10) will diminish morbidity compared to conventional lateral thoracotomy. This technique and the indications still need further investigation, before it can be accepted as a standard procedure. Combined anterior and dorsal approach of which the anterior approach can be performed in a thoracoscopic technique, with or without diaphragm splitting to reach for example the second lumbar vertebral body can be applied to spinal fractures of the thoracolumbar junction [2;4;8;9]. Mini lumbotomy for anterior approach of lumbar spinal fracture treatment can be an alternative for the thoracoscopic part of the operation, and can be performed in more distal fractures as well (L3-L5) [5].

Computer navigation will help to position the screws in the pedicles and will help to diminish roentgen exposure to patients and surgeons. Generally spoken, in clinical research concerning spinal fractures and its treatment, it is important that we do not only evaluate the radiological results. All (new) procedures will have to be evaluated more thoroughly than we used to do, including evaluation of morbidity by blood loss and complications, late results, functional outcome, quality of life and cost-effectiveness.

Very interesting research is going on and preliminary results have been published in the following fields:

- Fluoroscopic and computerized planning and peroperative navigation in spinal fracture treatment in order to perform more precise positioning of pedicle screws to avoid pedicle fractures, neurological complications and loosening of the pedicle screws [23].
• Titanium cages to replace a part of the fractured vertebral body in spinal fracture treatment to facilitate reduction, fixation and interbody fusion [15].
• Balloon vertebroplasty with calcium phosphate cement augmentation for direct restoration of traumatic thoracolumbar vertebral fractures [30].
• MRI and 3D-MRI diagnostic evaluation of spinal fractures, including discs and ligaments [22].

We have started the following studies in the field of spinal fractures:
• A prospective randomised trial in two centres of A-type spinal fractures without neurological involvement conservatively or operatively treated (USS) in the Free University Hospital in Amsterdam and the University Hospital Groningen. Evaluation of radiological results, morbidity, quality of life, impairments, costs, etc (Siebenga, Bakker, Patka, Haarman, Leferink, Zimmerman, ten Duis)
• Functional outcome in non operative spinal fracture treatment in 33 patients, comparable to the study described in chapter 6, including bicycle ergometry, lifting tests, RMDQ, VAS Spinal Score, SF-36 (Keizer, van der Sluis, Leferink, ten Duis)

![The SpinalMouse® is run paravertebrally from C7 to the rima ani](image)
Table 1 Data as stored and supplied by the software of the SpinalMouse®. Patient 3 years after operative treatment of a spinal fracture level L1, type A3.1. See text for explanation.

<table>
<thead>
<tr>
<th>Segment</th>
<th>Static test data</th>
<th>Range of motion data</th>
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<td>Flexion</td>
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<td>0</td>
</tr>
<tr>
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<td>3</td>
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<tr>
<td>T3/4</td>
<td>9</td>
<td>4</td>
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<tr>
<td>T4/5</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
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<td>2</td>
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<tr>
<td>T8/9</td>
<td>5</td>
<td>6</td>
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<td>7</td>
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<tr>
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<td>6</td>
<td>7</td>
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<td>T11/12</td>
<td>6</td>
<td>16</td>
</tr>
<tr>
<td>T12/L1</td>
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</tr>
<tr>
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<td>-1</td>
<td>2</td>
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<td>612</td>
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</table>

Fig.2 Sagittal shape of the back and inclination angles (C7-S3) in flexed (1), upright (2) and extended (3) position (same patient as Table 1). Black dot = T7
• Validation of the SpinalMouse®, a new device to measure segmental range of motion (interobserver error of a sample of measurements) (Post, Leferink: submitted, Fig.1)
• ROM study, non radiographical measurements of segmental ROM, with SpinalMouse® and its relation to subjective functional outcome as measured in RMDQ and VAS Spine Score in three groups of persons: operatively treated patients with spinal fractures after 3 to 5 years, conservatively treated patients with spinal fractures after 3 to 5 years and healthy volunteers (Post, Leferink: submitted)

SpinalMouse®

The SpinalMouse® technically seems to be an appropriate device to incorporate in regular follow-up evaluation of spinal fracture patients from one year after the operative treatment. The measurements are very easily taken by rolling the wheels of the computer mouse like device paravertebrally from C7 to S3 (rima ani) (Fig.1).

The length of the back, the local inclination to the plumb line and the sagittal shape of the back is measured in upright, flexed and extended position of the back. These data are send to the computer. The data are stored and immediate calculations supply data about ROM per segment (!) and these are available on the computer screen for comparison with normal values (age and sex specific) and for comparison with previous (interval) data of the same individual.

The data are provided as numerical tables (Table 1) and graphic illustrations as well, including the comparison with normal values (Fig.2 and Fig.3). It will supply feed back data to direct and control the rehabilitation process. This feed back will also benefit patients regaining confidence in posture and movement of the back.

As a first step in the validation of the SpinalMouse® we analysed interobserver errors of inclination measurements and measurements of the length of the back in different positions. In this respect it is important to analyse the calculated results as well, because some systematic errors will disappear in the calculations. For example systematic measurements of C7-S1 in stead of C7-S3 will not result in (large) interobserver errors in the measurements flexion-upright and extension-upright and flexion-extension. Interpretation of the values of the measurements will be subject of a clinical study. The results can easily be printed and given to the patient as an encouragement to do physical training exercises. It is expected that subjective improvement can be demonstrated and visualized. Eventually the value of the device will have to be determined in larger clinical studies.
Fig. 3 Graphic demonstration of the calculated measurements of segmental ROM: flexion, extension and flexion-extension, compared to age and gender specific normal values. See text for explanation

Recommendations

This thesis evaluates the radiological outcome and the functional outcome of operatively treated patients with spinal fractures of the thoracolumbar transition. We were able to make and explore a database of all 183 patients operated in 8 years in the surgical department in the University Hospital Groningen. Certain aspects, suggested in literature, could definitively be confirmed, for example progressive loss of regional angle and intervertebral angle. The comprehensive classification should be revised, including more aspects of soft tissue lesions, in order to avoid undertreatment of B-type lesions. Spontaneous remodelling of the spinal canal and the (observed) positive effect of transpedicular bone grafting still needs further investigation. Future research should be directed to diagnostics of soft tissue lesions and its predictive value, functional outcome, including ROM, objective and subjective findings in follow up, and computer navigation for safer procedures.
References


