Unstable fractures of the spine. Surgical methods. Synthesis of the injured dorso-lumbar spine by plates screwed into vertebral pedicles

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The reduction of spinal fractures requires a combination of faith and reason. Faith is needed, as the goal of the 20th century orthopaedic surgeon is to restore full integrity to the patient. Faith must be combined with reason, to ensure that the reduction procedure is safe for the spinal cord and nerve roots. Reduction should be followed by stable fixation. When the indications are determined with discernment and the procedure conducted methodically, surgery, an aggressive act that should always be mitigated by experience, now allows the reduction and stabilisation of spinal dislocations and, in the event of neurological compromise, ensures that the patient is in the best possible conditions for recovery.

1. Fixation material

The placement of screws into the pedicles is both the original feature and the challenge of our method. The pedicle is an extremely resilient sagittal structure, composed chiefly of cortical bone with a small amount of cancellous bone in its centre. A screw inserted into the pedicle has a firm purchase in the bone, and its tip penetrates into the vertebral body, which is less strong. We used spinal measurements to design special plates having a fixed width of 10 mm to match the width of the thoraco-lumbar para-spinal gutter. The regular 13-mm intervals separating the holes match the mean distance between the pedicles and articular processes.

The plates are pre-shaped to fit the usual contours of the spine, particularly at the thoraco-lumbar junction. They are fairly malleable and can therefore be re-shaped to fit the contours of an abnormal deformity or spinal fracture. A bump in the thickness of the plate opposite each hole ensures that plate strength is continuous and identical all along the length of the plate. Plates with 4, 5, 7, 9, 11, and 15 holes are available to match the spinal segment requiring fixation.

2. Operative technique

– Approach: caution and minimisation of bleeding are essential. Bleeding can be limited by performing the dissection as close as possible to the spinous processes and laminae. Caution includes refraining from the use of rasps or of the large Lucas-Championnière scissors without visual guidance. After exposure of the lesion, various procedures are performed as appropriate, such as laminectomy; reduction of the fracture-dislocation by direct manoeuvres using spatulas or a Farabeuf forceps grasping the spinous processes; or changes in the position of the traction table, which we believe should be used routinely.

– Identification and preparation of the pedicles for screw insertion: the insertion site, at both the thoracic and the lumbar segments, is just at the lower edge of the joint space. The joint space is directed sagittally and is easy to identify at the lumbar spine, where the insertion site is about 1 mm below, and on the same line as, the joint space. At the thoracic spine, the joint space is in the coronal plane and is more difficult to identify, as it is masked by the inferior articular process. The insertion site is 1 mm below the lower edge of the inferior articular process. A square-tipped awl is used to prepare the bit penetration site. The drill trajectory should be perpendicular in all planes to the vertebral of interest and strictly in the sagittal plane. A medially directed trajectory carries a risk of injury to the dura mater and a laterally directed trajectory a risk of poor screw purchase.

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Radiographs are helpful for determining the screw trajectory. They are used to estimate the transverse diameter, assess the projection of the pedicle relative to the joint space on antero-posterior views, and assess the direction of the pedicles in the sagittal plane on the lateral views.

- **Implantation of the fixation plates:** the length of the plate is selected so that each of the pedicles on the ends of the construct is located opposite a hole in the plate. The other holes may match the insertion sites in the other pedicles exactly. Otherwise, as a result of inter-individual variations, it may be necessary to use a hole located above or below the insertion site then to direct the drill upwards or downwards. Drilling should be performed using a slow motor, to improve accuracy and allow clear perception of the penetration of the bit. The bit penetrates a single cortex and remains in continuous contact with the bone over 35 to 45 mm. The antero-lateral cortex of the vertebral body should always be left intact. The two screws at the ends are engaged, while drilling of the intermediate pedicles is performed according to the position of the holes. Then, the screws are tightened simultaneously. The second plate is implanted and the articular process screws, whose length does not exceed 15 mm, provide additional anchorage.

- **Extent of the fixation:** for fractures of the vertebral body, it is necessary and sufficient to include two vertebrae above and two below the fractured vertebra. In contrast, in pure dislocations with minimal anterior collapse of the vertebral body, a shorter construct can be used.

- **Wound closure** on a suction drain.

- **Post-operative management:** In the absence of vertebral body dislocation, early ambulation with a plaster cast or moulded leather brace can be allowed as soon as the skin wound is healed. In the event of complete vertebral body dislocation, however, ambulation must be postponed until complete healing is achieved. Patients with paraplegia are always managed without bracing and can be placed in the seated position as soon as the vasomotor disturbances in the lower limbs are stabilised then placed in a weight-bearing position when allowed by their general condition.

3. **Therapeutic indications**

We believe that the indications for internal fixation rest on the presence of neurological signs and on the type of fracture. Fixation is indicated for the following fracture types:

- unstable fractures involving the middle vertebral segment with disruption of one or more of the following structures: posterior wall, articular processes, and pedicles; in the complete form, the entire vertebral ring is disrupted;

- certain pure fractures of the vertebral body with a coronal line that detaches a large anterior fragment, a pattern known as the ‘diabolo burst fracture’ and associated with a risk of vertebral non-union.

At the thoracic spine, given the uncertain results of conservative management, surgery should be performed if the vertebral body collapse is 30° or greater.

In pure vertebral body crush fractures, we continue to rely on gentle rehabilitation therapy combined with reduction by hyperlordosis and immobilisation in a Boehler cast if the fracture involves more than one-third of the vertebral body.

4. **Results**

- **Posterior internal fixation was performed in 68 patients** with thoraco-lumbar spinal fractures seen at the Poissy Hospital Centre between 1970 and 1975.

- There were 40 men and 28 women with a mean age of 32 years (range, 14-66 years) and a mean follow-up of 22 months (range, 10 months to 4 years). We included 12 patients with a follow-up of only 10 months because at that time point their fractures had been fully healed for at least 2 months.

- The topographic distribution of the lesions was consistent with classical descriptions. Thus, 59% of the lesions involved T11, T12, L1, and L2.

- In 54 cases, internal fixation was performed because of the presence of neurological disorders. The remaining 14 patients had comminuted fractures with spinal malalignment but no neurological disorders.

  Stabilisation should be assessed based on the vertebral body (bone) and spinal curvatures (disc and ligament).

a) **Changes in the vertebral body** ([Table 1](#tab1))

- In 62 patients, the vertebral body deformity was equal to or greater than 20°; reduction was considered excellent in 45 of these patients, good but insufficient in 14, and mediocre or absent in 3.

- Among the 11 patients with 50% reduction, 7 had insufficient reduction lordosis. In the remaining 4 cases, however, the vertebral body contour was not restored despite sufficient lordosis. These fractures raise the theoretical problem of using anterior approaches for reduction and arthrodesis.

b) **Changes in the disc**

- Perfect restoration of the spinal curvatures was achieved in 47 of the 65 patients.

- Overall angle correction loss measured on the endplates of the vertebrae adjacent to the fractured vertebral body was 0° in 18 patients, 5° in 9 patients, 5° to 10° in 17 patients, and 10° to 20° in 3 patients.

We believe that an angle correction loss of 10° or less is normal given the hyperlordosis needed to achieve reduction and the movements of the screws allowed by the plate.

c) **Changes in the fixation material**

No cases of plate breakage were recorded. However, in 17 patients, one or both of the lower distal screws broke. These screws were inserted in the lumbar spine, where mobility is greatest. Screw breakage has no adverse effects if it occurs after healing is obtained.

In 1 patient, screw breakage on day 60 resulted in 3° of displacement in the vertebral body and 20° of displacement in the disc. In 13 patients, the fixation material was removed after fracture healing was confirmed. Mean angle correction loss in the disc and ligaments was 6.3° in these cases compared to 4.4° in the patients whose material was left in place. In no case did spinal dislocation occur after removal of the material.

d) **Neurological syndromes** ([Table 2](#tab2))

Follow-up data were available for 51 patients with neurological disorders. Injury to the thoracic spinal cord (22 patients) always proved permanent, except for recovery of one or two metanemas at either end. In contrast, injury to the cauda equina or nerve roots at their emergence from the spinal canal (28 patients) was followed by a substantial degree of recovery in all cases (with complete recovery in 5 cases).

<table>
<thead>
<tr>
<th>Initial findings</th>
<th>Quality of the reduction</th>
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<tbody>
<tr>
<td>&gt; 30° → 18 cases</td>
<td>100%: 25 cases</td>
</tr>
<tr>
<td>20 to 30° → 30 cases</td>
<td>80%: 14 cases</td>
</tr>
<tr>
<td>62 cases</td>
<td>75%: 6 cases</td>
</tr>
<tr>
<td>20 → 14 cases</td>
<td>70%: 1 cases</td>
</tr>
<tr>
<td>0 → 6 cases</td>
<td>60%: 2 cases</td>
</tr>
<tr>
<td>14-66 cases</td>
<td>100%: 25 cases</td>
</tr>
<tr>
<td>51 cases</td>
<td>80%: 14 cases</td>
</tr>
<tr>
<td>30%: 1 case</td>
<td>100%: 25 cases</td>
</tr>
<tr>
<td>50%: 11 cases</td>
<td>100%: 25 cases</td>
</tr>
<tr>
<td>40%: 1 case</td>
<td>100%: 25 cases</td>
</tr>
<tr>
<td>0%: 1 case</td>
<td>100%: 25 cases</td>
</tr>
</tbody>
</table>

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Table 2
Neurological disorders (51 cases with follow-up data).

<table>
<thead>
<tr>
<th>Initial abnormalities</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 complete spinal cord injury</td>
<td>recovery 0</td>
</tr>
<tr>
<td>1 partial spinal cord injury</td>
<td>complete recovery 1</td>
</tr>
<tr>
<td>17 cauda equina lesions</td>
<td>recovery (2 to 4 metameres) 17</td>
</tr>
<tr>
<td>1 complete nerve root injury (L3)</td>
<td>subtotal recovery 1</td>
</tr>
<tr>
<td>10 partial nerve root injury</td>
<td>recovery (subtotal) 5</td>
</tr>
<tr>
<td></td>
<td>total 5</td>
</tr>
</tbody>
</table>

Table 3
Absence of neurological compromise (14 surgically treated cases).

- Comminuted fractures: 12
- Dislocations: 2
- Mean age: 31 years (15…64)
- Pain: None: 10
- Sporadic: 3
- Continuous but tolerable: 1
- Return to work: 6 women: 7.6 months, 8 men: 4.8 months
- Job change: 0: 11 sedentary lifestyle, 2 manual labour (4 months)

e) Functional, social, and occupational outcomes (Table 3)
None of the 14 patients without neurological disorders experienced incapacitating pain; all patients who had been working at the time of the injury returned to their previous jobs, including 2 manual labourers, after 2 months.

f) Complications
- Death: 2 patients died of thoracic complications related to multiple trauma; 1 patient died on day 8 of a massive pulmonary embolism.
- Suppuration: 5 patients, of whom 2 recovered after early excision and 3 required removal of the material after fracture healing, which had no adverse consequences.
- Worsening of the neurological disorders: 3 patients
  - Transient worsening in 1 patient;
  - Incomplete secondary syndrome 8 days after internal fixation in 1 patient, who achieved a partial recovery; given the symptom-free interval, we believe that a role for the surgical procedure cannot be considered certain;
  - Transient nerve root syndrome in 1 patient, due to contusion during incorrect drilling of a pedicle.

Disclosure of interest
Authors’ disclosure of conflict of interest was not requested when the article was originally published.