Hook–rod with pedicle screw fixation for unstable spinal fracture

Technical note

MARIN F. STANČIĆ, M.D., VLADIMIR MIČOVIĆ, M.D., AND MARK POTOCNJAK, M.D.

Department of Neurosurgery, General Hospital, Pula, Croatia

A technique is described in which spinal fracture repositioning, decompression, and stabilization are achieved by a combination of hook–rod and pedicle screw fixation. This straightforward technique is useful for performing acute decompression in patients with partial neurological deficits and multisystem injuries. A laminectomy allows for placement of a stiffer fixation system, and it improves the insufficient canal clearance obtained when performing annulotaxis alone.

KEY WORDS • annulotaxis • burst fracture • hook–rod system • pedicle screw • fixation • lumbar spine

C

ombined anterior–posterior surgery is a recommended technique for the treatment of unstable thoracolumbar fractures.13 This procedure is time consuming, invasive, and expensive; therefore, its use for the treatment of acute decompression in patients with multisystem injuries is questionable.3,11,13 Posterior surgery has the most acceptable parameters,3 but the effects of annulotaxis on the compressed spinal canal are sometimes inadequate.2 Laminctomy can be used to decompress the spinal canal further and to improve spinal canal clearance to a satisfactory level. The greatest disadvantage of a laminectomy procedure is that it destabilizes the spine by exaggerating spinal deformity.2 Failure of pedicle screw fixation techniques, even in cases in which a laminectomy has not been performed, has been observed.10 These hardware failures are related primarily to excessive preload forces introduced at the time of surgery, as well as to excessive flexion loading.1

We hypothesized that a hook–rod distraction system could be a suitable adjunct to pedicle screw fixation in load bearing. The proposed fixation system is twice as stiff as the conventional posterior fixation system, which has been previously confirmed by mathematical modeling;14 furthermore, in using this technique, laminectomy can be combined with annulotaxis to improve neurodecompressive effects that would only be partially achieved by performing the latter technique alone. The use of hook–rod distraction and pedicle screw fixation is illustrated in six cases.

Surgical Technique

The two vertebrae above and the one below the fractured vertebra are visualized via the posterior approach following measurement of kyphotic deformity, vertebral body height loss, and spinal canal encroachment (Fig. 1 left). Monoaxial pedicle screws (MOSS-Miami; DePuy, Warsaw, IL) are placed in the vertebra below the fracture, and thinner polyaxial screws are placed in the vertebra above the fracture. The screws are connected with rods, and distraction is performed. A laminectomy of the fractured vertebra is performed if encroachment of spinal canal is greater than 50%. The laminae are prepared for hook placement. Two interlaminotomies are drilled above the supralaminar surface of the vertebra, into which monoaxial screws are inserted, and two polyaxial screws are placed below the infralaminar surface of the vertebra. Four laminar hooks are inserted into the widened interlaminar spaces in distraction mode and connected with the rods. The construct is distracted until the hooks and rods are snug. The polyaxial screw–rod junctions are disconnected, and polyaxial screws are replaced with thicker and longer monoaxial screws. Following distraction of the hook–rod system, axially unloaded pedicle screws are connected with the rods at a right angle to create the strongest junction (Fig. 1 center). The rods of both fixation systems are linked with the transverse connector to increase torsion strength (Fig. 1 right). Free-fat tissue is
placed on the exposed dura, and intertransverse corticocancellous plates and cancellous bone strips are packed.

Illustrative Cases

This technique was performed in six patients with unstable lumbar burst fractures. Data on the age and sex of the patients; mechanism of injury; involved vertebra; type of fracture according to the Denis classification; American Spinal Injury Association grade at admission; time from injury to operation; operative time; blood loss; associated complications; American Spinal Injury Association grade at 1-year follow-up examination; economic and functional rating scores according to the Prolo scale; and follow-up duration are shown in Table 1.

Case 2

This 37-year-old man sustained three spinal column fractures of L-2 after falling from a 7-m height while working as a manual laborer. On admission, muscle strength in both legs was 0/5. Sensitivity to pain and temperature was lost below the L-1 level, but proprioceptive sensation was preserved. Rib fractures on the right side, with lung contusion, were also observed. Preoperative vertebral body height loss was 60%, kyphosis 15°, and spinal canal encroachment was 90% (Fig. 2 upper left). Emergency surgery was indicated, and a posterior approach was chosen because of the patient’s concomitant chest trauma. Five hours postinjury posterior surgery was performed using both hook–rod distraction and pedicle screw fixation with laminectomy. Postoperative x-ray films demonstrated that anatomical repositioning had been achieved; residual ventral canal encroachment was 40% (Fig. 2 upper center). At 3-month follow-up examination the patient could ambulate and was continent and pain free. At 1-year follow up there was no recurrent kyphosis, no residual spinal canal encroachment, and the patient had returned to his work and to recreational activities (Fig. 2 upper right).

<table>
<thead>
<tr>
<th>Case Number</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>age (yrs), sex</td>
<td>40, F</td>
<td>37, M</td>
<td>60, M</td>
<td>16, M</td>
<td>36, M</td>
<td>35, M</td>
</tr>
<tr>
<td>type of accident</td>
<td>fall</td>
<td>fall</td>
<td>fall</td>
<td>MVA</td>
<td>MVA</td>
<td>fall</td>
</tr>
<tr>
<td>involved vertebra</td>
<td>L-1</td>
<td>L-2</td>
<td>L-3</td>
<td>L-2</td>
<td>L-1</td>
<td>L-2</td>
</tr>
<tr>
<td>Denis fracture type</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>B</td>
<td>E</td>
</tr>
<tr>
<td>ASIA grade at admission</td>
<td>C</td>
<td>B</td>
<td>D</td>
<td>C</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>injury–op time (hrs)</td>
<td>7</td>
<td>5</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>op time (min)</td>
<td>240</td>
<td>210</td>
<td>110</td>
<td>210</td>
<td>270</td>
<td>200</td>
</tr>
<tr>
<td>blood loss (L)</td>
<td>1.7</td>
<td>0.7</td>
<td>0.6</td>
<td>0.9</td>
<td>1.1</td>
<td>0.7</td>
</tr>
<tr>
<td>complication</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>ASIA grade at follow up</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>†Prolo scale</td>
<td>E4/F5</td>
<td>E5/F5</td>
<td>E5/F5</td>
<td>E5/F5</td>
<td>E5/F5</td>
<td>?</td>
</tr>
<tr>
<td>follow up (yrs)</td>
<td>4</td>
<td>2</td>
<td>1.5</td>
<td>1</td>
<td>1</td>
<td>0.5</td>
</tr>
</tbody>
</table>

* ASIA = American Spinal Injury Association; MVA = motor vehicle accident; ? = not known.
† Prolo economic and function rating scale: E4 = working at previous occupation on part-time or limited basis; E5 = working at previous occupation with no restrictions of any kind; F5 = complete recovery of function, no recurrent low-back pain, and able to perform all previous sports activities.
Hook–rod system with pedicle screw fixation

**Case 6**

In the patient in Case 6 we found that only one rod with hooks was sufficient to achieve correction of his lateral flexion burst fracture (Denis Type E) (Fig. 3).

**Discussion**

**Biomechanical Rationale for Using a Double Posterior Fixation System**

The hook–rod distraction system is a three-point bending construct that corrects spinal deformity by applying dorsal-ly directed forces at the upper and lower construct–bone interfaces as well as equal ventrally directed force at the fulcrum. Shortening the distance between the fulcrum and hook increases flexion-resisting forces. Anteriorly placed instrumentation in benchmark combined surgery resists flexion forces in the anterior column. We have hypothesized that hook–rod distraction combined with pedicle screw fixation can supplement anterior–posterior fixation. In this load sharing, combination hook–rod instrumentation participates with axial load bearing. If the pedicle screw fixation is not in distraction, it functions as cantilever beam with a firmly fixed moment arm. The rigid buttresslike nature of the ventral...
screw portion of the pedicle screw system resists flexion forces and eliminates the need for placement of an anterior interbody strut graft and instrumentation.

The indirect reduction of a fractured vertebra by performing annulotaxis clears only approximately 50% of the compromised spinal canal area. Postoperative canal encroachment greater than 20% is unacceptable, and further decompression by performing a laminectomy provides one possible solution. A laminectomy is suitable when combined with the hook–rod pedicle screw fixation system, because the proposed fixation is stiffer than that achieved by the conventional posterior fixation system, as has been previously confirmed.

Rationale for Acute Posterior Surgery

Although the authors of clinical studies do not encourage provision of early neurodecompression, the results of experimental work suggest that surgery can be performed within a time window of 8 hours. The incidence of multisystem injuries in patients with unstable thoracolumbar fracture is 52%. Anterior surgery is indicated in patients in whom there is evidence of at least 40% ventral canal compromise, 40% or greater loss of vertebral body height, and/or kyphosis measuring at least 15°. Posterior stabilization must additionally be performed when a posterior column injury has caused instability. In place of anterior–posterior surgery in patients with multisystem injuries, shorter, less invasive, and less costly surgery may be more appropriate for achieving early decompressive effects.

The operative time and blood loss associated with this combined hook–rod pedicle screw fixation procedure is comparable with those obtained via the posterior approach by using the classic technique. In contrast, results of combined anterior–posterior and cross-screw fixation procedures show significantly higher values for these parameters.

No complications were observed in our six patients. No chronic pain was demonstrated, although an additional motion segment undergoes fixation as compared with anterior–posterior surgery. However, this motion segment is commonly part of a less mobile thoracic aspect of the vertebral column.

Conclusions

Our preliminary results suggest that the combined hook–rod pedicle screw fixation technique can be a good alternative to combined anterior–posterior surgery for performing acute neurodecompression while maintaining measures of neuroprotection in patients with multisystem injuries.

Acknowledgment

We thank Mrs. Jelena Čepo for technical assistance.

References

Hook–rod system with pedicle screw fixation


Manuscript received May 19, 1999.
Accepted in final form September 2, 1999.
Address reprint requests to: Marin F. Stančić, M.D., Sisplac 5, HR-52100 Pula, Croatia. email: marin.stancic@pu.tel.hr.