Stabilisation of fractured thoracic and lumbar spine with Cotrel-Dubousset instrument

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ABSTRACT

Objective. To evaluate the effectiveness of 2 different types of Cotrel-Dubousset instrument systems in stabilising thoracolumbar and lumbar spine fractures.

Methods. Between January 1989 and December 1993, 45 fractures in 42 patients with unstable fracture or fracture dislocation of the thoracolumbar and lumbar spines were randomly assigned to 2 surgical treatments with Cotrel-Dubousset instrumentation—using either a long segment (Group 1) or a short segment (Group 2)—and short posterolateral fusion.

Results. Consolidation of the fractured vertebral body and posterolateral fusion were achieved at a mean time of 4.5 months; fusion rates were 75% in Group 1 and 83% in Group 2. The average collapses of anterior vertebral body height in Group 1, in the immediate postoperative period and at the final follow-up, were 15% and 17%, respectively; and in Group 2, the figures were 16% and 24%, respectively. The correction of vertebral height and kyphosis at the last follow-up were lost more in Group 2 (5.7°) than in Group 1 (4.4°). There were neurological recoveries in 6 of the 9 cases of incomplete paraplegics, including complete recovery in 5, and one-Frankel grade increase in one. There were 15 instrument failures in 12 patients, including screw breakage in 3 Group 1 cases and 6 Group 2 cases. The plug dislodged in 3 Group 1 cases, and the hook dislodged in 3 Group 2 cases. In other words, instrument failures were more common in Group 2.

Conclusion. Cotrel-Dubousset stabilisation of the fractured spine achieves fracture consolidation, but does not maintain the restored height and sagittal curve completely until fusion. The long rod and short fusion construct was more effective for all fracture types than was the short rod and fusion construct, although it leads to wider immobilisation of normal segments.

Key words: Cotrel-Dubousset; spinal fracture; spinal fusion
INTRODUCTION

The goals of surgical management of unstable fractures of the spine include attainment of the normal spinal anatomy, as well as maintenance of reduction, decompression of the neurological structures, and early mobilisation.1–3 Although immediate reduction and stabilisation of a fractured spine by using hook or pedicular screw instrumentation can be achieved postoperatively, loss of reduction can occur during follow-up. Therefore, maintenance of the reduced fracture and restored spinal curvature has been a main concern even after instrumented stabilisation.1,2,4–6 Some surgeons have stressed the application of the load-sharing principle in the surgical treatment of the fractured spine on the basis of numerical instability indices.7

In this study, we evaluated the 2 types of Cotrel-Dubousset instrumentation constructs for thoracolumbar and lumbar spine fractures.

Figure 1  (a) Example of long-rod construct between T12 and L3. (b) Wedged burst fracture of L2 was treated with instrumented stabilisation utilising Cotrel-Dubousset system: 2 vertebrae above (one hook and one pedicle screw) and one below (hook in lamina and screws in pedicle in L3). (c and d) Fracture site at 3 and 10 months postoperatively; the fractured L2 vertebra postoperatively restored its height and maintained its shape, though the L1-2 disc space gradually narrowed.
MATERIALS AND METHODS

We studied 45 fractures in 42 patients who were treated at the Catholic University Affiliated Hospitals, Seoul, Korea, between January 1989 and December 1993 for unstable fracture or fracture dislocation of the thoracolumbar and lumbar spines. In all, there were 33 men and 9 women, with a mean age of 34.5 years (range, 18–57 years). All patients were treated with Cotrel-Dubousset instrumentation systems and posterolateral fusion, and they were followed up for 32 to 72 months. The causes of injury were as follows: falls from a height (n=30), slip injuries on stairs (n=3), hang-glider crashes (n=3), traffic injuries (n=3), and industrial injuries (n=3); 21 patients had associated fractures in the calcaneus (n=12), tibia (n=6), and pelvis (n=3).

Surgeries were performed, on average, 9.9 days after injury (range, 1–24 days). In all patients without fracture dislocation, the fractures were reduced by the contoured rods to apply the lordotic distraction principle, a deformity correction method by rotating...

Figure 2  (a) Example of short-rod construct of a burst fracture with posterior dislocation of L3. (b) Fracture instrumented: posterior fixation with pedicle screws and posterolateral fusion after reduction was performed. (c) and (d) During follow-up, there was gradual recollapse of L3 body owing to trauma-induced anterior column deficiency with resultant fracture of left upper pedicle screw.
the contoured rods into opposite direction, without primary vertical distraction or compression force. In Group 1 cases, reduction involved the 2 vertebrae above the fracture site (compression hook attached to the second upper vertebra and pedicle screw attached to the first upper vertebra) and the first lower vertebra (combined pedicle screw and compression hook) [Fig. 1]. In Group 2 cases, the vertebrae immediately above and below the fractured vertebrae were fixed posteriorly with pedicle screws, and were fused posterolaterally with autogenous iliac bone graft (Fig. 2). Anterior surgery was not performed to stabilise the anterior column additionally in any of the patients.

The anterior vertebral height and local kyphotic angle were measured radiographically before and after surgery, and at the last follow-up. Degree of bone loss in patients older than 55 years was assessed preoperatively on plain X-rays, by using Saville’s method to rule out the poor surgical indication. The osteoporosis index was Grade I in most cases, and did not correlate with implant failure (Table 1). In addition, computed tomography was performed for all patients to classify the fracture type, and to assess the neural canal encroachment by the retropulsed middle column fragment.

21 cases were bursting fractures, 15 were flexion-distraction injuries, and 9 were fracture dislocations; 3 patients had both L1 flexion-distraction fracture and L3 bursting fracture (Table 2). All fractures involved different degrees of corporal comminution or wedging, which suggests recollapse even after instrumented reduction and stabilisation. Nine patients had incomplete neurological deficits.

24 patients with relatively severe shattered
fractures received Group 1 treatment: 12 had relatively severe burst fractures, 9 had flexion-distraction in-juries, and 3 had fracture dislocations. 18 patients with less severe shattered fractures received Group 2 treatment: 9 had slight burst fractures, 3 had flexion-distraction injuries, and 6 had fracture dislocations (Table 3). In 9 patients with neurological deficit (6 with fracture dislocations and 3 with burst fractures; assigned to both groups), decompression surgery was combined: reduction of fracture dislocation and reduction of retropulsed fragment.

15 patients were allowed to walk at the end of postoperative 2 weeks, 21 at 3 weeks, 3 at 6 weeks, and 3 at 3 months, according to the systemic and neurological recovery rate and speed of each individual patient. 30 patients in the first half of the current series wore a custom-made orthosis, but an orthosis was not prescribed for the remaining patients.

By taking serial X-rays, we assessed fusion on the basis of Lenke’s criteria of fusion mass. Anterior vertebral heights and kyphosis angles were measured to determine the effectiveness of the 2 types of posterior instrumentation construct.

RESULTS

Consolidation of the fractured vertebral body and posterolateral fusion were achieved after a mean period of 4.5 months (range, 3–7 months) after surgery. The fractured vertebral body consolidated in all cases; in 3 cases, posterolaterally grafted bone was not visible, but became stable in the last follow-up radiographs. The posterolateral fusion rate was 79% on average of all cases: 75% in Group 1, and 83% in Group 2 (Table 4).

In Group 1 cases, the average preoperative local kyphosis angle was 20.3° and the immediate post-operative and last follow-up angles were 7.0° and 11.4°, respectively. The postoperative increase of kyphosis was thus 4.4°. In Group 2 cases, the average pre-operative kyphosis angle was 14.7° and the immediate postoperative and last follow-up angles were 2.4° and 8.1°, respectively. The overall postoperative increase of kyphosis was hence 5.7°. Postoperatively, kyphosis was corrected by more than 10.0° in 18 (75%) of the 24 patients in Group 1, and in 12 (67%) of the 18 patients in Group 2. At the last follow-up, loss of corrected kyphosis exceeded 10.0° in 3 cases of fracture

<table>
<thead>
<tr>
<th>Fusion</th>
<th>Group 1 (n=24)</th>
<th>Group 2 (n=18)</th>
<th>Total (n=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type A</td>
<td>6 (0)*</td>
<td>9 (3)</td>
<td>15 (3)</td>
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<tr>
<td>Type B</td>
<td>9 (3)</td>
<td>3 (3)</td>
<td>12 (6)</td>
</tr>
<tr>
<td>Type C</td>
<td>3 (0)</td>
<td>3 (3)</td>
<td>6 (3)</td>
</tr>
<tr>
<td>Type D (non-union)</td>
<td>6 (0)</td>
<td>3 (0)</td>
<td>9 (0)</td>
</tr>
<tr>
<td>Fusion rate</td>
<td>75%</td>
<td>83%</td>
<td>79%</td>
</tr>
</tbody>
</table>

* Implant failure cases in brackets

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<tr>
<th></th>
<th>Time of observation</th>
<th>Loss of correction at the last follow-up (range)</th>
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<tbody>
<tr>
<td>Local kyphotic angle</td>
<td></td>
<td></td>
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<tr>
<td>Group 1</td>
<td>20.3° (3.0°–2.0°)</td>
<td>11.4° (0.0°–25.0°) 4.4° (9.0°–16.0°)</td>
</tr>
<tr>
<td>Group 2</td>
<td>14.7° (1.0°–29.0°)</td>
<td>8.1° (7.0°–25.0°) 5.7° (0.0°–12.0°)</td>
</tr>
<tr>
<td>Anterior vertebral height loss</td>
<td></td>
<td></td>
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<tr>
<td>Group 1</td>
<td>46% (31%–62%)</td>
<td>17% (-8%–46%) 3% (0%–18%)</td>
</tr>
<tr>
<td>Group 2</td>
<td>40% (31%–53%)</td>
<td>24% (2%–43%) 8% (0%–24%)</td>
</tr>
</tbody>
</table>
dislocation of Group 1, and in 3 cases of fracture dislocations and 6 bursting fractures of Group 2 (Table 5). However, final kyphosis did not exceed 25.0° in any case.

In Group 1 cases, loss of the average anterior vertebral heights preoperatively, immediately postoperatively, and at the last follow-up were 46%, 15%, and 17% of the normal values, respectively; the overall postoperative increase of height loss was 3%. In Group 2 cases, loss of the anterior vertebral heights preoperatively, immediately postoperatively, and at final follow-up were 40%, 16%, and 24% of the normal values; the overall postoperative loss in the regained height was 8%. In 12 cases of Group 1, percentile height restoration exceeded 30%, but not in Group 2. At the last follow-up, the number of patients in whom loss of the restored height exceeded 5% was 3 (all were fracture dislocations) in Group 1, and 9 (3 fracture dislocations and 6 bursting fractures) in Group 2 (Table 5).

There were neurological recoveries in 6 of 9 incomplete cases: 5 cases of complete recovery, and one case in which Frankel’s grade increased by one; there were no changes in the remaining 3 patients (2 with Frankel’s grade at C, and one at grade D at the last follow-up).

Complications

Among 12 patients, there were 15 instrument failures: screw breakage in 9 cases (3 in Group 1, and 6 in Group 2), plug dislodgement in 3 (all belong to Group 1), and hook dislodgement in 3 (all belong to Group 2) [Table 6]. No signs of screw toggling were observed in any patient. Deep wound infection with disruption occurred in one patient, but this condition was well controlled after wound debridement and irrigation together with antibiotic therapy.

DISCUSSION

Before introduction of instrumented stabilisation surgery for the unstable spine, spine fractures, with or without cord injury, were mostly treated conservatively, although Moon et al. introduced non-instrumented anterior interbody fusion of the fractured spine in 1981. The Harrington system was developed for treatment of spinal scoliosis in 1958. Almost one decade later, the system began to be used to stabilise the fractured spine, despite the description of posterior pedicular screwing and plate fixation of the spines by Boucher in 1959, which was not popularised for a while. However, both systems were gradually replaced with new stabilisation systems that provided more secure fixation. After that, many different pedicular screw systems have been developed. They have many advantages, such as effective reduction of displaced or shattered fractures, segmental control of motion in three dimensions, preservation of motion segments by the avoidance of long fusions, and provision of a more stable construct.

Early pedicular screw instrumentation was reported to be very successful in reduction and maintenance of reduction until bony consolidation of the fractured vertebral body and fusion. However, many surgeons experienced instrument failures and loss of fracture reduction. Daniaux et al. reported a 19% screw breakage rate, and Carl et al. reported 10 (22%) instrumentation failures among 45 fractures. They explained that in vivo stresses that might cause minor realignment changes with Harrington hook and rod fixation might also cause screw failure with the more rigid Cotrel-Dubousset pedicle screw system. Gurr and McAfee found that Cotrel-Dubousset instrumentation placed 2 levels above and 2 levels below an unstable calf spine model provided more stiffness than the intact spine. Krag suggested segmental pedicle fixation 2 levels above the kyphosis to prevent implant failure. Furthermore, Carl et al. reported that segmental pedicular fixation 2 levels

<table>
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<tr>
<th>Cause of failure</th>
<th>Group 1</th>
<th>Group 2</th>
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<tbody>
<tr>
<td>Screw breakage</td>
<td>3*</td>
<td>6</td>
</tr>
<tr>
<td>Plug dislodgement</td>
<td>3*</td>
<td>0</td>
</tr>
<tr>
<td>Hook dislodgement</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>6</td>
<td>9</td>
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* The same patients
above the kyphosis should be used at the thoracolumbar junction, where compression forces act more anteriorly. In contrast, in the more lordotic middle and lower lumbar spine, where the compressive forces act more posteriorly, no implant failures occurred with the ‘one above, one below construct’.

The results of our study suggest that posterior long-segment instrumented stabilisation can provide more secure fixation than does the use of a short-segment rod for the unstable fractured spine with anterior column insufficiency, thereby avoiding implant failure. The use of the modular type of short Cotrel-Dubousset rod cannot effectively maintain the fracture reduction before consolidation of the fractured vertebrae, and the incidence of metal fatigue failure thus cannot be reduced in patients treated by short-segment stabilisation and early postoperative mobilisation.

To get rid of these demerits of the Cotrel-Dubousset modular system, a new construct has been introduced: pedicle screw fixation of 3 vertebrae including the fractured vertebra. In this system, the construct is fixed to one vertebra above the fracture, the fractured vertebrae, and one vertebra below the fracture. The construct is very effective for reduction and stabilisation of the fractured vertebra, and could replace the original Cotrel-Dubousset modular short-segment stabilisation construct.

Postoperative loss of the restored vertebral height and kyphosis after pedicular instrumentation has been reported by many authors. In Carl et al’s series, kyphosis improved at a mean of 7.4° immediately postoperatively, but the improvement decreased to 6.4° at follow-up, and the Wedge index went from 0.71 preoperatively to 0.77 postoperatively, and to 0.74 at final follow-up. In our series, loss of correction of local kyphosis angle and anterior vertebral height at last follow-up were greater and more common in the short-segment fixation group than in the long-segment fixation group, although the posterior fusion rate was not influenced by length of the instrumented segments.

Recollapse of the regained vertebral height and increase of kyphosis after the instrumented reduction of the fractured vertebra were mainly attributable to the defective anterior column in the fractured vertebral body that resulted during the instrumented deformity correction. It is thought that recollapse of the regained height of the fractured vertebral body will not develop if an anterior defect is not made by over-correction and/or over-distraction of the shattered vertebral body at the time of the instrumented fracture reduction and fixation. Again, there will be less or no metallic failure or screw loosening in bone, if an anterior column defect is not produced in the fractured vertebral body by the instrumented fracture reduction procedure, or if additional anterior stabilisation surgery is combined in the presence of definite anterior column defect. Therefore, we strongly recommend that the long rodding rather than short rodding in the treatment of the unstable fractures, and that the reconstruction of the defective anterior column if an anterior column defect is made by the posterior instrumented reduction procedure of the fractured vertebral body.

CONCLUSION

Two Cotrel-Dubousset instrumentation constructs for the fractured thoracolumbar and lumbar spines could effectively restore the collapsed and fractured vertebral body initially, but could not maintain the restored vertebral height and sagittal curve completely until consolidation of fractured vertebral body and solid posterior fusion of the spine. Long Cotrel-Dubousset instrumentation was more effective in stabilising the fractured spine with less instrument failure than was the short Cotrel-Dubousset instrumentation, regardless of fracture type except for the classical seat-belt injury. Posterolateral fusion of the fracture area did not help maintain the fracture reduction and prevent the failure of the fixation metal during fracture consolidation. Posterolateral fusion rates were not influenced by length of the instrumented motion segments.

REFERENCES