Two kinds of posterior approach for Kümmell’s disease after osteoporotic thoracolumbar fracture

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Objective: To compare the surgical results of two kinds of posterior approach for osteoporotic thoracolumbar Kümmell’s disease.

Methods: Clinical and radiographic results of 1-segmental pedicle screw fixation combined with vertebroplasty (Group A, n=12) or posterior shortening osteotomy (Group B, n=16) for osteoporotic thoracolumbar Kümmell’s disease were analyzed retrospectively. Japanese orthopedic association (JOA) and visual analogue scale (VAS) scores were used for clinical evaluation. Neurological status was judged by Frankel grades. X-ray was used to evaluate the radiographic results. Complications related to operation and devices were also considered.

Results: The follow-up period was 12-54 months (average 29 months). Pre- and post-operative VAS were 9.3 and 3.2 in Group A, 8.9 and 2.5 in Group B, respectively. The mean JOA score at the final follow-up was significantly higher than that of pre-operation (t=5.306, P<0.001). There was no significant difference between Groups A and B (t=0.618, P>0.05). The kyphosis were corrected from preoperative 33.9°(A)/37.3°(B) to postoperative 10.3°(A)/6.5°(B), and 15.3° (A)/13.7° (B) at the final follow-up. There was a significant difference between the two groups at the final follow-up. Frankel grade was improved from grade C preoperatively to postoperatively grade D or E in 7 cases of Group A and 5 cases of Group B, from grade D to E in 5 cases of Group A and 11 cases of Group B. The mean improvement was 1.6 and 1.7 grades for Groups A and B, respectively. There were no serious complications related to internal fixation.

Conclusions: The similar clinical results can be obtained by the two kinds of posterior surgical methods for osteoporotic Kümmell’s disease. Posterior spinal shortening is a better choice for patients with serious kyphosis combined with neurological deficit than the other.

Key words: Osteoporosis; Fractures, bone; Surgical procedures, operative

The incidence of osteoporotic thoracolumbar fractures increases with aging. Delayed post-fracture vertebral collapse or un-union, i.e. Kümmell’s disease, can occur in osteoporotic aging spine.1-2 Vertebroplasty or kyphoplasty can be used for some cases without spinal cord compression. However, Kümmell’s disease may have posterior cortex breakage with neurological compression, which is a relative contraindication for this technique.3-4 In such cases, it has been treated by posterior spinal shortening procedure of segmental fixation or anterior decompression and reconstruction.5-6 The posterior procedure is technically demanding and highly risky. However, the anterior approach usually involves long operation time and may cause injuries of the internal organs. Accordingly, we used vertebroplasty technique combined with one-segmental pedicle screw fixation for stage III Kümmell’s disease from March 2006 to May 2008 and obtained satisfactory preliminary results. This report attempts to compare the surgical results of two kinds of posterior approach (vertebroplasty combined with one-segmental fixation vs posterior spinal shortening) for osteoporotic thoracolumbar Kümmell’s disease.

METHODS

Clinical data

Grouping All patients with osteoporotic thoracolumbar Kümmell’s disease were divided into 2 groups according to surgical methods. In Group A, 12 cases, 4 males and 8 females, were treated with manual reduction, vertebroplasty combined with one-segmental pedicle screw fixation (Fig.1.A-D). The mean age at...
the time of surgery was 67.3 years (range: 56-77 years). The levels of fracture vertebrae were T₁₂ in 4 cases, L₁ in 7, and L₂ in 1. In Group B, 16 cases, 6 males and 10 females, were treated with posterior spinal shortening technique (Fig. 2.A-B). The mean age at the time of surgery was 64.6 years (range: 53-80 years). The fracture vertebrae were T₁₂ in 7, L₁ in 6 and L₂ in 3. There was no significant statistical difference between the two groups with regard to patients' age, gender, fracture vertebrae, Japanese orthopedic association (JOA) and visual analogue scale (VAS) and neurological functional evaluation (P>0.05, Table 1).

Table 1. The demographics comparison of two groups before operation (x±s)

<table>
<thead>
<tr>
<th>Groups</th>
<th>Age (years)</th>
<th>Gender</th>
<th>Fracture vertebrae</th>
<th>JOA score</th>
<th>VAS</th>
<th>Frankel grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>67.3±4.1</td>
<td>4</td>
<td>8</td>
<td>4 7 1</td>
<td>12.5±3.3</td>
<td>9.1±0.4</td>
</tr>
<tr>
<td>B</td>
<td>64.6±3.5</td>
<td>6</td>
<td>10</td>
<td>7 6 3</td>
<td>11.9±3.1</td>
<td>8.7±0.6</td>
</tr>
<tr>
<td>t</td>
<td>1.449</td>
<td>0.004</td>
<td>0.245</td>
<td>0.805</td>
<td>0.836</td>
<td>0.886</td>
</tr>
<tr>
<td>P</td>
<td>0.187</td>
<td>0.995</td>
<td>0.992</td>
<td>0.374</td>
<td>0.418</td>
<td>0.985</td>
</tr>
</tbody>
</table>

Fig. 1. L₁ compress fracture 10 months after trauma. A: 17° kyphosis angle can be seen on lateral X-ray film. B: Cleft in fractured vertebral body and spinal canal encroachment can be seen on CT scan. C: Local low signal on MRI T₁-weight and high signal on MRI T₂-weight in fractured vertebral body can be seen, which indicates lesion hydrops and bone necrosis sign. D: Postoperative X-ray film. E: X-ray film at postoperative 20 months after vertebroplasty combined with one-segmental pedicle screw fixation.
Inclusion criteria  Primary osteoporosis, single-level stage III Kümmell’s disease, limited disease of vertebral fracture from T₁₂ to L₁ were included. Kümmell’s disease was diagnosed by intravertebral cleft sign on CT scan or osteonecrosis with fluid signal on MRI. Pathological vertebral fracture induced by primary tumor, metastatic neoplasm and other causes should be excluded. Neurological function status was limited to Frankel C-D. Symptom duration was 6-14 months. All patients received standard conservative treatment for 3 months, which included lying in bed, wearing stiff brace and taking anti-osteoporosis medication. No severe complications in the heart and lung were detected.

Surgical procedure
Vertebroplasty combined with one-segmental pedicle screw fixation  Twelve patients received manual reduction and one-segmental pedicle screw fixation with posterior body reconstruction augmented by bone cement. A patient received general anesthesia and was put in a prone position under somatosensory evoked potential monitoring. Then manual reduction was done as follows: one anesthesiologist held the patient’s head; two assistants held the patient’s shoulders; one assistant held the patient’s legs; and the surgeon compressed the fractured vertebra. The reduction result can be detected under C-arm fluoroscopy. Satisfactory reduction result should be maintained. Then the fracture level and adjacent segment (the vertebrae near to end-plate fracture) were exposed. Bilateral pedicle tunnels to the fractured vertebral body were made by awl, followed by mark pin, which should be checked under C-arm fluoroscopy. The bony defect in the fractured vertebral body was filled through bilateral pedicle tunnels with 2-6 ml bone cement. Then pedicle screws were placed into the fracture level and the adjacent normal vertebra using the rod screw system (Fig.1.A-D). Bilateral inter-laminal window’s decompression should be performed, and then to detect posterior wall fragment reduction result of vertebral body. Local laminectomy autograft was placed over bilateral facet bed.

Fig.2. T₁₂ fracture. A: Myelography indicates dural sac compression, spinal canal encroachment on CTM and MRI. B: Postoperative X-ray film. C: X-ray film at postoperative 20 months after posterior spinal shortening technique combined with pedicle screw fixation.
Posterior spinal shortening technique The patient was placed prone after general anesthesia. A midline incision was made and dissection was extended along the spinous process. Then the fracture level and adjacent segment (the vertebrae near to end-plate fracture) should be exposed and up to the transverse process in the lateral direction. The lamina and caudal facet joints in the fractured vertebra were resected. After the cutting of the transverse processes, the lateral outer cortex of the vertebral body was explored along the outer cortex of the pedicle. Thereafter the pedicle screws were inserted into the above and below vertebrae. The following procedures were performed with a contralateral rod setting. In the spinal canal, the fractured posterior cortex was osteotomized by a small special chisel and the necrotized intravertebral cancellous bone was removed by forceps with a gentle retraction of the dural tube. In the lateral portion, the posterior cortex below the pedicle was resected with retracting the nerve root cephaladly. In some cases, the additional resection of the caudal part of the pedicle was necessary. The posterior part of the vertebral body became empty after these procedures. After the complete decompression of the spinal cord, two rods were set bilaterally. Compression force was added to the screws along these rods until the two end plates came in contact with each other. As a result, the end plates became parallelled to each other. Additionally, posterolateral fusion was performed using the resected spinous process and the laminae.

Postoperative treatment At 2-3 weeks after operation, all patients were braced for out-of-bed activities for 3 months postoperatively. Anti-osteoporotic medication including calcitonin, diphosphate, vitamin D, and calcium was used routinely. Comprehensive rehabilitation such as electromagnetic stimulation, acupuncture, positive muscles exercises can be selected according to neurological functional status and ability of daily life.

Postoperative evaluation Clinical results were evaluated by VAS (10 points) and means of recovery rate of JOA (29 points) scores. Recovery rate of clinics by JOA scores was calculated using the following formula: (postoperative score – preoperative score)/(29 – preoperative score) × 100%. Neurological functional status was judged by Frankel grades. Fusion status and kyphosis correction results were determined by X-ray films. Cobb’s method was used for the evaluation of kyphosis (measurement by Kuklo’s suggestion). Complications were also discussed, such as breakage, migration or loosening of instruments, bone cement leakage, infection, neurological injury, and so on.

Statistical analysis SPSS 10.0 software was used for statistical analysis. Measurement data including operation time, blood loss, JOA scores, and kyphosis Cobb’s angle were analyzed by t test. Numeration data such as numbers of fractured vertebra and Frankel grades used precise probability calculation. P<0.05 was considered statistically significant.

RESULTS Mean follow-up periods of all patients was 29 months (range:12-54 months). There was no statistical difference between Group A and Group B on VAS, JOA scores and its recovery rate (P>0.05). Both surgical bleeding and operation time in Group A were less than those in Group B significantly (P<0.05). The residual kyphosis Cobb’s angle of Group A was statistically greater than that of Group B (P<0.05). For neurological status, in Group A, 7 cases recovered from Frankel C to Frankel D or E, 5 from D to E. In Group B, 6 cases recovered from Frankel C to Frankel D or E, 10 from Frankel D to E. The average recovery grades were 1.6 and 1.9 respectively. There was no significant difference between Groups A and B. The results of comparison is showed in Table 2.

Table 2. The results of comparison between Group A and Group B after operation

<table>
<thead>
<tr>
<th>Groups</th>
<th>Operation time (min)</th>
<th>Bleeding (ml)</th>
<th>JOA</th>
<th>VAS</th>
<th>Kyphosis angle (°)</th>
<th>Recovery rate (%)</th>
<th>Frankel (grade)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>106 ± 26</td>
<td>150 ± 62</td>
<td>26.8 ± 4.3</td>
<td>2.6 ± 0.7</td>
<td>13.6 ± 1.3</td>
<td>85.6 ± 12.7</td>
<td>1.6</td>
</tr>
<tr>
<td>B</td>
<td>197 ± 39</td>
<td>766 ± 46</td>
<td>26.2 ± 3.1</td>
<td>2.7 ± 0.6</td>
<td>0.9 ± 1.7</td>
<td>83.9 ± 11.3</td>
<td>1.9</td>
</tr>
<tr>
<td>t</td>
<td>6.992</td>
<td>2.380</td>
<td>0.638</td>
<td>0.537</td>
<td>3.603</td>
<td>0.397</td>
<td>0.734</td>
</tr>
<tr>
<td>P</td>
<td>0.0001</td>
<td>0.034</td>
<td>0.514</td>
<td>0.647</td>
<td>0.001</td>
<td>0.712</td>
<td>0.417</td>
</tr>
</tbody>
</table>
As for intraoperation complications, in Group A, bone cement leakage into spinal canal occurred in 3 cases. Suction tube sinus tract was formed in 1 diabetic patient and closed in 2 weeks. In Group B, there was 1 dural tear recognized and repaired during operation. One case suffered from transient nerve injury and recovered completely 3 weeks later. Kyphosis correction loss rate in Group A was higher than that in Group B. There were no infection, death or other device-related complications such as loosening, breakage, and so on.

**DISCUSSION**

Osteoporotic thoracolumbar compression fractures are frequent in aged patients. It is a common cause of low back pain for old patients. Routine conservative methods including lying in bed, wearing thoracolumbar brace, proper exercises and medications can obtain satisfactory results in most cases. But for some patients, vertebral necrosis or un-union, even delayed post-traumatic vertebral collapse often occurs in an osteoporotic spine, which also called Kümmell’s disease.\(^1\)\(^-\)\(^3\)\ Hein\(^9\) reported that 36% vertebral compression fracture is progressive, and conservative treatment is not effective for these aging cases with cord compression. For the aged patients, long-term lying in bed can induce many complications, some of which are fatal. Surgical intervention is necessary for such conditions. There are some significant clinical challenges and disputes when performing surgical treatment for osteoporotic vertebral collapse with neurological deficits.\(^2\)\(^,\)\(^5\)\(^,\)\(^6\)

Manual reduction allowed safe reduction of the fractured vertebra and decompression of the spinal cord in acute non-osteoporotic burst fracture. Reduction and stability can be obtained by short-segment posterior fixation (one above, one below).\(^10\) After at least 2 years follow-up, we found that trans-fracture vertebral body one-segmental pedicle screw fixation can obtain good results for the treatment of fresh thoracolumbar fracture.\(^7\) Therefore, we applied this method combined with traumatic body vertebroplasty for osteoporotic thoracolumbar Kümmell’s disease. Preoperative proper traction and trunk extension reduction can make anterior column open, leading to kyphosis improvement and indirect decompression. After trans-pedicle vertebroplasty of traumatic segment is performed, pedicle screws are implanted into it bilaterally, which can reinforce the pull-out strength. Biomechanical study has confirmed the significant superiority of this technique.\(^11\) From the clinical follow-up results of Group A, manual reduction and trunk extension can restore the traumatic segmental alignment for stage III Kümmell’s disease. Vertebroplasty enhancement is helpful to maintain vertebral body height and prevent the pull-out of pedicle screws. Both of the measurements produce good clinical results. There is no internal fixation lossening. Vertebral body height and neurological function improvement can be maintained during the follow-up period for Group A. This simple technique needs short operation time without much bleeding. So it is suitable for these patients who are not good in general health and can not endure spinal shortening procedure. It can relieve pain quickly and stabilize fracture body instantly. Kung et al\(^12\) reported that posterior short-segmental pedicle screw fixation combined with fracture body vertebroplasty resulted in satisfactory results on kyphosis correction, neurological function improvement and low back pain relief. But the procedure we used in the study has some advantages as follows: microinvasive procedure, short segment fixation and little bleeding. Nonetheless, its long-term outcome still needs further clinical observation.

Posterior spinal shortening technique used for delayed osteoporotic vertebral fracture was reported initially by Saita et al\(^12\). Its advantages included good decompression results, satisfactory kyphosis correction, sufficient fusion, and internal fixation safety. Sixteen cases were treated by this method in the current study. Some modification was developed in a few cases according to the fracture type. For instance, autografts were implanted into fractured vertebral body to improve the support and union ability. Because the strength of pedicle cortex and subcortex of the osteoporotic spine was decreased, pedicle screw used merely was prone to loosening. So laminar hook and transverse process hook were used at the same time in order to enhance the screws’ pull-out strength, which would make good stability and was useful for bone union. Pedicle screw-hook combination were used for 5 cases in Group B. Multi-anchor is helpful to disperse stress. In order to reduce the risk of the device loosening, one or more segments included in fixation range should be fixed if necessary, such as fixation range spanning 1 segment above and below the fractured vertebrae in 5 cases, 2 segments above and below the fractured vertebrae in 4 cases, 2 segments above and 1 segment combined...
with laminar hook below the fractured vertebrae in 7 cases in this group. The outcome indicates that this technique can result in satisfactory kyphosis correction and maintain the correction during the follow-up period. Suki et al\textsuperscript{13} reported that closed spinal osteotomy technique could maintain kyphosis correction. From the point of biomechanics, the spinal shortening procedure has some advantages. Uchida et al\textsuperscript{14} found that the pedicle screw was prone to loosening when distraction plus short segment fixation technique were used. In order to obtain satisfactory fixation-fusion results, laminar (or transverse process) hook should be used for osteoporotic patients. In Group B, the neurological function and low back pain were improved remarkably and no internal fixation device loosening occurred during follow-up periods. All fracture vertebral body acquired union, kyphosis correction was maintained. On the whole, this procedure is more suitable for those cases who are in good general health, with severe kyphosis, demanding high level of life quality postoperatively.

The surgical indication for osteoporotic thoracolumbar fracture needs further study and identification. However, the following several factors should be taken into consideration: (1) general health of patients, (2) type, level, and number of fractures, (3) degree of osteoporosis, and (4) the best possible technique to achieve decompression and correct kyphosis. To successfully treat unstable vertebral collapse with bony fragments retroplused into the spinal canal and resulting in neurological deficits, direct decompression of the nerve tissue and reconstruction of the spinal column are required. JOA score, VAS and Frankel grading were used in this study to compare the operative outcome of the two methods. There is no significant difference on clinical and radiographic results between two groups. Methods of Group A have the following advantages: shorter operation time, less bleeding, and more segments conservation. It is suitable for aged patient with serious comorbidities. Spinal shortening technique can be selected for these patients who are in good general health and with large kyphotic angle. In short, comprehensive evaluation for each patient is the most important step when surgeons choose a surgical procedure.

REFERENCES


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