Correlation of kyphosis and wedge angles with outcome after percutaneous vertebroplasty: a prospective cohort study

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ABSTRACT

Purpose. To evaluate the correlation of kyphosis and wedge angles with pain relief and functional outcome after percutaneous vertebroplasty (PV).

Methods. 15 men and 19 women aged 41 to 85 (mean, 62) years who presented with osteoporotic wedge compression fractures of the dorsolumbar spine below T5 and had failed conservative treatment were included. Patients were assessed before and one year after PV. Kyphosis and wedge angles were measured on standardised radiographs. Pain and function were assessed using the visual analogue scale (VAS) score and the Ronald Morris Disability Questionnaire (RMDQ) score, respectively. Patients were dichotomised based on their preoperative kyphosis (≤10º vs. >10º) and wedge angles (≤7º vs. >7º). Outcomes were classified as excellent, fair, and poor in terms of VAS scores (<3, 3–6, >6) and RMDQ scores (<8, 8–16, >16). Correlations between the kyphosis and wedge angles and VAS and RMDQ scores were assessed.

Results. VAS and RMDQ scores correlated positively with the kyphosis and wedge angles; the highest correlation was between the VAS score and kyphosis angle (r=0.93). A significantly greater proportion of excellent outcomes (in terms of RMDQ and VAS scores) were noted in patients with preoperative kyphosis and wedge angles of ≤10º and ≤7º, respectively.

Conclusion. PV is a viable treatment for vertebral compression fractures with regard to pain relief and improvement of function. Preoperative kyphosis and wedge angles were predictive of post-PV outcomes in terms of VAS and RMDQ scores.

Key words: kyphosis; osteoporotic fractures; vertebroplasty

INTRODUCTION

Vertebral compression fractures usually occur in elderly, osteoporotic persons after trivial trauma. Percutaneous vertebroplasty (PV) was first used in the treatment of aggressive haemangiomas, but
now is more commonly used to treat osteoporotic fractures. When the loss of vertebral height is <50%, most patients respond well to conservative management and the treatment for osteoporosis, but some respond poorly and continue to have pain and other symptoms. PV is a simple and viable treatment for such fractures with respect to pain relief and restoration of alignments, kyphosis and wedge angles, and vertebral height. Restoration of alignment and height improves the deformity and spinal dynamics, and has an effect on the functional outcome and post-procedure fractures, as well as quality of life and pain. Various factors have been studied, including age, gender, level of fracture, and bone mineral density (BMD). However, only one study reported correlation between restoration of height and functional outcome. It is unclear whether angular and height restoration affect functional outcome and whether alignment should be restored. We therefore evaluated the correlation of kyphosis and wedge angles with pain relief and functional outcome after PV.

MATERIALS AND METHODS

This study was approved by the ethics committee of the Sancheti Institute of Orthopaedics and Rehabilitation. Informed consent from each patient was obtained. Between June 2006 and December 2008, 15 men and 19 women aged 41 to 85 (mean, 62) years who presented with osteoporotic wedge compression fractures of the dorsolumbar spine (Denis type-1) below T5 and had failed to heal after conservative treatment (bed rest for 6 weeks; use of analgesics, muscle relaxants, and brace support for 3 months) were included. Patients with neurological involvement, fractures secondary to bone tumours, multiple fractures, cardiopulmonary disorders, or evidence of spinal infection were excluded. The mean duration of complaint was 4 (standard deviation [SD], 1; range, 3–8) months. Their mean BMD was -3.1 (SD, 0.5; range, -2.5 to -3.9); 20 patients had osteoporosis and 14 were osteopenic, whereas 9 of the 34 patients were smokers.

PV was performed under local anaesthesia, with monitoring by an anaesthesiologist. The pedicles were localised using an image intensifier, and a 0.5-cm paramedian incision was made on either side of the spine for insertion of the 10-gauge trocar-cannula system. Using the transpedicular route, the needle was centred at the 10 o'clock position over the left pedicle or 2 o'clock position over the right pedicle on the anteroposterior view. The needle was medialised through the cylinder of the pedicle to reach the middle of the vertebra. The needle was advanced under the guidance of lateral fluoroscopy after the first cortex was pierced and a footprint was obtained by the needle in the pedicle. As this area is relatively devoid of venous plexuses, the ideal endpoint was the junction between the anterior and middle third of the vertebral body (Fig. 1). To minimise the risk of extravasation, cement was slowly injected while viscous under the guidance of lateral C-arm imaging. The patient was kept prone until the cement hardened (usually 5 minutes).

Postoperatively, patients had to maintain bed rest. On day 1, patients were allowed to mobilise with a walker and taught strengthening exercises. On day 2, patients were discharged and continued the physiotherapy at home. External bracing was not provided. Calcium supplements and bisphosphonates were administered. The sutures were removed on day 12.

Patients were assessed before and one year after PV. Kyphosis and wedge angles on standardised radiographs (plate tube distance, 100 mts) were measured using digital software (Fig. 2). Magnification did not alter measurement of the angles. Pain and function were assessed using the visual analogue scale (VAS) score and the Ronald Morris Disability Questionnaire (RMDQ) score, respectively. Patients were dichotomised based on their preoperative kyphosis (≤10º vs. >10º) and wedge angles (≤7º vs. >7º). Outcomes were classified as excellent, fair, and poor in terms of VAS scores (<3, 3–6, >6) and RMDQ scores (<8, 8–16, >16).
Pre- and post-operative angles were compared using the paired \( t \) test. Percentages in different categories were compared using the Chi squared or Fisher’s exact tests as appropriate. A \( p \) value of <0.05 was considered statistically significant. Correlation coefficients between the kyphosis and wedge angles and VAS and RMDQ scores were assessed.

RESULTS

The mean amount of cement used per level was 3.8 (SD, 0.8; range, 2.5–5) ml. The outcome (VAS and RMDQ scores) was excellent in 27 patients, fair in 4, and poor in 3. The mean VAS score improved 74% from 8 to 2 \( (p<0.001) \); the mean RMDQ score improved 77% from 19 to 5 \( (p<0.001) \); the mean kyphosis angle improved 11% from 9° to 8° \( (p<0.001) \); the mean wedge angle improved 13% from 6° to 5° \( (p<0.001) \) [Table 1]. VAS and RMDQ scores correlated positively with kyphosis and wedge angles; highest correlation was between the VAS score and kyphosis angle (Table 2).

In 26 and 8 patients, the preoperative kyphosis angle was <10° and ≥10°, respectively (Table 3). In the 26 patients, outcome was excellent in 24 and fair in 2 \( (p=0.003) \). In the remaining 8 patients, outcome was excellent in 3, fair in 2, and poor in 3 \( (p=0.009) \). Preoperative kyphosis angle strongly positively correlated with the VAS score \( (r=0.93) \) and the RMDQ

### Table 1
Comparative analysis of variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>Preop</th>
<th>Postop</th>
<th>Change (%)</th>
<th>( p ) Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ronald Morris Disability Questionnaire score</td>
<td>19±2</td>
<td>5±5</td>
<td>77</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Visual analogue scale score</td>
<td>8±1</td>
<td>2±2</td>
<td>74</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Kyphosis angle</td>
<td>9°±7°</td>
<td>8°±6°</td>
<td>11</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Wedge angle</td>
<td>6°±3°</td>
<td>5°±3°</td>
<td>13</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

* Paired \( t \) test

### Table 2
Correlation between the kyphosis and wedge angles and visual analogue scale (VAS) and Ronald Morris Disability Questionnaire (RMDQ) scores

<table>
<thead>
<tr>
<th>Variables</th>
<th>Correlation coefficient ( (r) )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kyphosis angle</td>
</tr>
<tr>
<td></td>
<td>Preop</td>
</tr>
<tr>
<td>VAS score</td>
<td>0.93</td>
</tr>
<tr>
<td>RMDQ score</td>
<td>0.87</td>
</tr>
</tbody>
</table>

Figure 2  Radiographs showing (a) L1 compression fractures (b) and one year after percutaneous vertebroplasty.
score \((r=0.87)\).

In 24 and 10 patients, the preoperative wedge angle was \(<7^\circ\) and \(\geq 7^\circ\), respectively (Table 3). In the 24 patients, outcome was excellent in 22 and fair in 2 \((p=0.014)\). In the remaining 10 patients, outcome was excellent in 5, fair in 2, and poor in 3 \((p=0.02)\). Preoperative wedge angle strongly positively correlated with the VAS score \((r=0.81)\) and the RMDQ score \((r=0.77)\).

Three patients had cement extravasation; none had cardiovascular or neurological complications, an increase in scoliosis, or infections. At the one-year follow-up, no patient had adjacent vertebral fractures.

### DISCUSSION

PV is a viable treatment for painful osteoporotic compression fractures in the elderly.\(^{24-29}\) Nonetheless, careful selection of patients and good surgical technique are mandatory for success.\(^{30,31}\) Two randomised trails considered PV ineffective.\(^{32,33}\) However, the fractures were 12 months old and may have healed.\(^{34,35}\) Other chronic spinal pathologies may have caused the symptoms, as most osteoporotic fractures resolve within 6 to 8 weeks.\(^{36}\) An intention-to-treat analysis would have been more appropriate, as patients refused to participate may create bias.\(^{34,37,38}\)

The sham procedure acts like a facet medial nerve block leading to pain relief in poorly selected elderly patients with facet arthritis.\(^{36}\) Multiple centres and different periods of patient recruitment also cause bias.\(^{37}\) The use of a 13-gauge needle and less cement may lead to inadequate filling of the clefts and thus stability.\(^{34,39}\)

PV should not be used just for pain relief; it should also be used for restoration of vertebral height and correction of alignments (kyphosis and wedge angles).\(^{4-6}\) These angles can be used as surrogate to estimate height restoration. Correction of alignments is linked to postural correction owing to positioning of the spine on bolsters.\(^{40-44}\) Intravertebral clefts and mobility of the fracture are associated with better correction.\(^{42,44}\) Vertebral height restoration does not correlate with quality-of-life outcome scores and pain relief, but correlation between outcome and correction of alignments was not measured.\(^{11}\) In our study, improvement in kyphosis and wedge angles was significant, and the positive correlation between these angles and VAS and RMDQ scores was strong. Thus, kyphosis and wedge angles can be prognostic indicators for the outcome of PV, and it would be

### Table 3

<table>
<thead>
<tr>
<th>Variables</th>
<th>Total no. of patients</th>
<th>No. (%) of patients</th>
<th>Outcome (VAS and RMDQ scores)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Excellent</td>
</tr>
<tr>
<td>Preop kyphosis angle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\leq 10^\circ)</td>
<td>26</td>
<td>24 (92)</td>
<td>2 (8)</td>
</tr>
<tr>
<td>(&gt;10^\circ)</td>
<td>8</td>
<td>3 (38)</td>
<td>2 (25)</td>
</tr>
<tr>
<td>p Value*</td>
<td></td>
<td>0.003</td>
<td>0.229</td>
</tr>
<tr>
<td>Postop kyphosis angle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\leq 10^\circ)</td>
<td>26</td>
<td>24 (92)</td>
<td>2 (8)</td>
</tr>
<tr>
<td>(&gt;10^\circ)</td>
<td>8</td>
<td>3 (38)</td>
<td>2 (25)</td>
</tr>
<tr>
<td>p Value*</td>
<td></td>
<td>0.003</td>
<td>0.229</td>
</tr>
<tr>
<td>Preop wedge angle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\leq 7^\circ)</td>
<td>24</td>
<td>22 (92)</td>
<td>2 (8)</td>
</tr>
<tr>
<td>(&gt;7^\circ)</td>
<td>10</td>
<td>5 (50)</td>
<td>2 (20)</td>
</tr>
<tr>
<td>p Value*</td>
<td></td>
<td>0.014</td>
<td>0.564</td>
</tr>
<tr>
<td>Postop wedge angle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\leq 7^\circ)</td>
<td>30</td>
<td>26 (87)</td>
<td>4 (13)</td>
</tr>
<tr>
<td>(&gt;7^\circ)</td>
<td>4</td>
<td>1 (25)</td>
<td>0 (0)</td>
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<tr>
<td>p Value*</td>
<td></td>
<td>0.0211</td>
<td>0.999</td>
</tr>
</tbody>
</table>

* Chi squared test
desirable to restore the maximum alignment.\textsuperscript{31}

In an \textit{in vitro} study on 6 fresh human cadavers,\textsuperscript{4} PV significantly improves the kyphosis angle, and the extent of improvement depends on the amount of cement used. Improvement of the respective kyphosis and wedge angles after PV has been reported to be 6° and 3.5°, and 19% and 44%.\textsuperscript{5,6}

The rates of adjacent vertebral fractures vary from 6 to 27%.\textsuperscript{45–48} Nonetheless, a very low rate has also been reported.\textsuperscript{49} Adjacent vertebral fractures correlate with the initial trauma and greater height restoration.\textsuperscript{5,47} The only significant risk factor of PV is cement extravasation into the disc space.\textsuperscript{50} PV is not at increased risk compared to conservative treatment; the number of vertebral body fractures correlates with increased risk of repeat fractures.\textsuperscript{51} The major shortcomings of our study were small sample size and short follow-up period.

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REFERENCES