Anterior bone cement augmentation in anterior lumbar interbody fusion and percutaneous pedicle screw fixation in patients with osteoporosis

Clinical article

KYEONG HWAN KIM, M.D., PH.D.,1 SANG-HO LEE, M.D., PH.D.,2 DONG YEOB LEE, M.D.,2 CHAN SHIK SHIM, M.D., PH.D.,2 AND DAE HYEON MAENG, M.D.3

1Department of Orthopedic Surgery, 2Neurosurgery, and 3Thoracic and Cardiovascular Surgery, Wooridul Spine Hospital, Seoul, Korea

Object. The purpose of the present study was to evaluate the efficacy of anterior polymethylmethacrylate (PMMA) cement augmentation in instrumented anterior lumbar interbody fusion (ALIF) for patients with osteoporosis.

Methods. Sixty-two patients with osteoporosis who had undergone single-level instrumented ALIF for spondylolisthesis and were followed for more than 2 years were included in the study. The patients were divided into 2 groups: instrumented ALIF alone (Group I) and instrumented ALIF with anterior PMMA augmentation (Group II). Sixty-one patients were interviewed to evaluate the clinical results, and plain radiographs and 3D CT scans were obtained at the last follow-up in 46 patients.

Results. The mean degree of cage subsidence was significantly higher in Group I (19.6%) than in Group II (5.2%) (p = 0.001). The mean decrease of vertebral body height at the index level was also significantly higher in Group I (10.7%) than in Group II (3.9%) (p = 0.001). No significant intergroup differences were observed in the incidence of radiographic adjacent-segment degeneration (ASD) or in terms of pain and functional improvement. The incidences of clinical ASD (23% in Group I and 10% in Group II) were not significantly different. There was 1 case of nonunion and 3 cases of screw migration in Group I, but none resulted in implant failure.

Conclusions. Anterior PMMA augmentation during instrumented ALIF in patients with osteoporosis was useful to prevent cage subsidence and vertebral body collapse. In addition, PMMA augmentation did not increase the nonunion rate and incidence of ASD. (DOI: 10.3171/2009.11.SPINE09264)

Key Words • anterior lumbar interbody fusion • pedicle screw fixation • osteoporosis • anterior cement augmentation

INSTRUMENTED LIF, whether anterior or posterior, immediately produces a biomechanically stable postoperative spine, which facilitates arthrodesis and improves clinical outcomes.5,16,18,21 However, in patients with severe osteoporosis, instrumented LIF may result in fixation failure or nonunion due to decreased pedicle screw pullout strength or an increased risk of interbody graft subsidence, which sometimes requires an additional surgery.12,14,19,20,23,27,31 Among the various methods used to overcome these problems, PMMA cement augmentation has yielded favorable results. Most previous studies on PMMA augmentation for LIF have been related to the posterior approach for obtaining bone-cement-screw bonding.6,7,9,10,29 Compared with posterior augmentation, anterior PMMA augmentation is thought to strengthen the anterior support more effectively because the central portion of the VB can be augmented by PMMA via the anterior approach. However, there has been no clinical study concerning anterior PMMA augmentation for LIF.

The purpose of this study was to introduce the technique of anterior PMMA augmentation in instrumented ALIF for patients with osteoporosis and to evaluate the clinical and radiological outcomes of anterior PMMA augmentation in these cases.
Methods

Patient Population and Data Collection

We selected 62 patients who underwent single-level ALIF with percutaneous PSF at L4–5 or L5–S1 between January 2004 and December 2006. All of these patients met the following inclusion criteria: 1) spondylolisthesis was initially diagnosed; 2) mean T-score of BMD at L1–4 was below –2.5; 3) ASD was not apparent; and 4) patient was followed for more than 2 years. Exclusion criteria were as follows: 1) cases involving revision surgery or infection; 2) presence of lumbar disc herniation or stenosis not associated with olisthesis; 3) multilevel instrumentation; and 5) any radiological evidence of vertebral column compression fracture. Selected patients were divided into 2 groups: instrumented ALIF alone (Group I) and instrumented ALIF with anterior PMMA bone cement augmentation (Group II).

Clinical Evaluation

An independent researcher interviewed all patients, except one in Group II who could not be interviewed due to a speech impediment. All questionnaires were supplemented by reviewing patients’ medical records. Before and after surgery, pain was measured using a visual analog scale (0–10) and function was assessed with the ODI (score range 0–100%). The clinical ASD was defined as 1) symptomatic spinal stenosis, 2) intractable back pain, or 3) subsequent sagittal or coronal imbalance, as suggested by Cheh et al. Symptomatic spinal stenosis was defined as stenosis diagnosed on radiological examination accompanied by clinical neurological claudication.

Radiological Evaluation

All patients underwent preoperative dynamic standing plain radiography and CT scanning. At last follow-up, however, 7 patients in Group I and 9 in Group II declined to undergo imaging because most of them had a favorable clinical outcome. As a result, we obtained dynamic standing plain radiographs and 3D CT scans at the last follow-up in 46 patients. Radiological measurements were blinded and performed by an orthopedic surgeon (K.H.K.) and a neurosurgeon (D.Y.L) not involved with the index operation. Radiological measurements were made using digitalized tools in the PACS system, PiView 1.0 (Infinitt Co. Ltd.). The radiological evaluation of the index level included degree of cage subsidence, collapse of the VB, and presence of nonunion. Bone union was defined as solid when there was osseous continuity in and/or around the cages on both the coronal and sagittal reconstructed CT scans and less than 4° of mobility on the lateral flexion/extension plain radiographs. Nonunion was defined as the presence of a visible gap on CT scans and/or motion greater than 4° on the lateral flexion/extension radiographs. Radiological parameters for evaluating the adjacent segment included changes of translation, angular motion, and disc height. Osteoarthritis of the facet joint was graded, as suggested by Weishaupl et al., and change in cranial VB height was also evaluated (Table 1). Radiographic parameters were measured twice at 1-week intervals, and average values of both observers were used as data. The radiographic ASD was diagnosed by the development of olisthesis greater than 4 mm, angular changes on flexion/extension lateral radiographs greater than 10°, or loss of disc height greater than 10%. Computed tomography was also used to diagnose ASD when the osteoarthritis grade of the facet had deteriorated in relation to the preoperative grade. Intervertebral disc height was measured by the average of the anterior and posterior heights on standing lateral radiographs. Vertebral body height was also measured on standing lateral radiographs and was the average of the anterior, middle, and posterior VB height. Difference by magnification was standardized with the anteroposterior diameter of the cranial VB at the upper-next segment of the cranial adjacent segment (Fig. 1). To investigate the maintenance of sagittal balance, we used the Cobb method to measure entire lumbar lordosis and the segmental lordotic angle of the index level on pre- and postoperative standing lateral radiographs.

To assess inter- and intraobserver reliability, the measurement of osteoarthritis grade of the facet was done twice at 1-week intervals and the data sets of the 2 different observers were compared and assessed. Statistical analysis was performed using SPSS software.

Technique of ALIF With Anterior PMMA Augmentation and PSF

The patient was placed in the supine position after induction of general anesthesia. The level of skin incision was confirmed with C-arm fluoroscopy and midline skin incision then was made. Following dissection of the subcutaneous adipose tissue, the anterior lamella of the rectus sheath was incised; after dissection of the posterior lamella of rectus sheath, the retroperitoneal space was then exposed. To expose the anterior longitudinal ligament at the index level, the peritoneal content was retracted to the medial side to expose the abdominal vessels. The great vessels were mobilized and then retracted medially. The ventral surface of the upper and lower VBs was confirmed by fluoroscopy. A 10-gauge vertebroplasty needle (Kyungwon Medical Co. Ltd.) was inserted into the upper and lower VBs at the intersection point between the vertical midline and the horizontal line at one-third of the vertebral body.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>normal facet joint space (2–4-mm width)</td>
</tr>
<tr>
<td>1</td>
<td>narrowing of the facet joint space (&lt;2 mm) &amp;/or small osteophyte &amp;/or mild hypertrophy of the articular process</td>
</tr>
<tr>
<td>2</td>
<td>narrowing of the facet joint space &amp;/or moderate osteophyte &amp;/or moderate hypertrophy of the articular process &amp;/or mild subarticular bone erosion</td>
</tr>
<tr>
<td>3</td>
<td>narrowing of the facet joint space &amp;/or large osteophyte &amp;/or severe hypertrophy of the articular process &amp;/or severe subarticular bone erosion &amp;/or subchondral cyst</td>
</tr>
</tbody>
</table>
the distance from the endplate, to place the cement mass near the endplate (Fig. 2). The vertebroplasty needle tip was then inserted into the central point on the lateral image under C-arm fluoroscopic guidance. Approximately 2–3 ml of PMMA, Osteobond Copolymer Bone Cement (Zimmer, Inc.), was injected in the dough phase. The location of the cement mass was limited to the middle one-third of the VB on both the anteroposterior and lateral image to avoid the trajectory of the pedicle screw (Fig. 3). Endplate preparation and insertion of the large wedge-shaped lordotic WSH cage (NHS Co. Ltd.), was performed after the cement had hardened and the heat generation had subsided. The cage was filled with mixture of allograft cancellous bone chip (Hans Biomed Corp) and 2.5 ml of demineralized bone matrix (Grafton, Osteotech Inc.). After the anterior procedure, the patient’s position was changed to prone. With the patient lying flat on the table with a radiolucent frame, a mini-open or percuta-
neous PSF was performed under fluoroscopic guidance. Before screw insertion, the trajectory of pedicle screws was confirmed using a probe or guide wire under C-arm fluoroscopy to ensure that it did not interfere with the centrally located cement mass.

Results

Patient Demographics

There were 3 males and 59 females enrolled in this study. Thirty-one patients underwent instrumented ALIF alone (Group I) and 31 underwent instrumented ALIF with anterior PMMA bone cement augmentation (Group II) (Table 2). The mean age of patients in Group I was 61 years (range 48–72 years) and that in Group II was 64 years (range 49–77 years). The mean follow-up period in Group I was 36 months (range 25–42 months) and that in Group II was 34 months (range 25–58 months). The mean T-score of BMD was −3.09 (range −2.5 to −4.5) in Group I and −3.28 (range −2.5 to −4.7) in Group II. The mean body mass index in Group I was 24.7 kg/m² (range 19.6–30.2 kg/m²), whereas that in Group II was 24.3 kg/m² (range 16.4–31.2 kg/m²). The ratio of index level (L4–5 vs L5–S1) was 20/11 in Group I and 22/9 in Group II. The ratio of index diagnosis (degenerative spondylolisthesis vs isthmic spondylolisthesis) was 20/11 in Group I and 17/14 in Group II. There were no intergroup differences in the demographic data.

Clinical Outcomes

The mean preoperative VAS score in Group I of 8.0 (range 5–10) improved to 3.3 (range 0–10) after surgery; the mean percentage improvement was 58.9% (range 0–100%) (Table 3). The mean preoperative VAS in Group II of 8.6 (range 5–10) improved to 3.2 (range 0–10) after surgery; the mean percentage improvement rate was 62.9% (range 0–100%). The intergroup difference in the percentage improvement rates of the VAS score was not significant. The mean preoperative ODI score in Group I of 57.6% (range 36–98%) improved after surgery to 22.6% (range 0–71%); the mean percentage improvement in the ODI score was 61.7% (range 0–100%). The mean preoperative ODI score of Group II of 63.2% (range 42–98%) improved to 21.5% (range 0–58%) after surgery; the mean percentage improvement of the ODI score in Group II was 66% (range 4–100%). There was no significant intergroup difference in the ODI improvement rates. Clinical success was defined as: ≥25% improvement rate in ODI score, ≥2-point improvement in VAS score, ≥50% patients’ subjective recovery rate, and no major complication related to the device, as suggested by Shim et al.25 According to these criteria, clinical success was seen in 22 (71%) of 31 Group I patients and 24 (80.0%) of 30 in Group II (with the one patient with a speech impediment excluded). The clinical success rate in Group II was higher than that in Group I, but the difference was not significant. Clinical ASD developed in 7 (23%) of 31 Group I patients and 3 (10%) of 30 Group II patients. The incidence of clinical ASD was higher in Group I, but the difference was not significant. Spinal stenosis symptoms were the most common clinical manifestations of clinical ASD (8 cases), and intractable back pain developed in 2 patients. No patients with clinical ASD needed additional surgery. All patients were treated with conservative modalities such as medication, nerve block procedure, and modification of life style, with regular follow-up.

Radiological Outcomes

The mean preoperative entire lumbar lordotic angle was −49.6° (range −65.7 to −15.3°) in Group I and −51.5° (range −64.8 to −35.0°) in Group II (Table 4). The mean

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**Table 2: Summary of demographic data in 62 patients**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Group I</th>
<th>Group II</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>no. of patients</td>
<td>31</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>male/female ratio</td>
<td>2/29</td>
<td>1/30</td>
<td>0.575*</td>
</tr>
<tr>
<td>mean age (yrs)</td>
<td>61</td>
<td>64</td>
<td>0.081†</td>
</tr>
<tr>
<td>mean follow-up (mos)</td>
<td>36</td>
<td>34</td>
<td>0.256†</td>
</tr>
<tr>
<td>mean BMD (T-score)</td>
<td>−3.09</td>
<td>−3.28</td>
<td>0.202†</td>
</tr>
<tr>
<td>mean body mass index (kg/m²)</td>
<td>24.66</td>
<td>24.25</td>
<td>0.587†</td>
</tr>
<tr>
<td>level (no. of patients)</td>
<td>0.589*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L4–5</td>
<td>20</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>L5–S1</td>
<td>11</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>spondylolisthesis (no. of patients)</td>
<td>0.441*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>degenerative</td>
<td>20</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>isthmic</td>
<td>11</td>
<td>14</td>
<td></td>
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</tbody>
</table>

* Fisher exact test.
† Independent t-test.

**Table 3: Clinical outcome**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Group I</th>
<th>Group II</th>
<th>p Value</th>
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<tbody>
<tr>
<td>no. of patients</td>
<td>31</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>mean ODI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>preop (%)</td>
<td>57.61</td>
<td>63.24</td>
<td>0.128*</td>
</tr>
<tr>
<td>postop (%)</td>
<td>22.55</td>
<td>21.48</td>
<td>0.824*</td>
</tr>
<tr>
<td>improvement rate (%)</td>
<td>61.66</td>
<td>65.96</td>
<td>0.562*</td>
</tr>
<tr>
<td>mean VAS score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>preop</td>
<td>8.03</td>
<td>8.60</td>
<td>0.137*</td>
</tr>
<tr>
<td>postop</td>
<td>3.27</td>
<td>3.17</td>
<td>0.793*</td>
</tr>
<tr>
<td>improvement rate (%)</td>
<td>58.94</td>
<td>62.88</td>
<td>0.668*</td>
</tr>
<tr>
<td>satisfaction rate (%)</td>
<td>62.94</td>
<td>66.83</td>
<td>0.667*</td>
</tr>
<tr>
<td>clinical success rate (%)</td>
<td>70.97</td>
<td>80.00</td>
<td>0.653†</td>
</tr>
<tr>
<td>clinical ASD (%)</td>
<td>22.55</td>
<td>10.00</td>
<td>0.301†</td>
</tr>
</tbody>
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* Independent t-test.
† Fisher exact test.
postoperative entire lumbar lordotic angle was $-58.2^\circ$ (range $-81.1$ to $-24.0^\circ$) in Group I and $-59.9^\circ$ (range $-72.8$ to $-33.6^\circ$) in Group II. Mean entire lumbar lordotic angle at the last follow-up was $-52.0^\circ$ (range $-80.0$ to $-21.9^\circ$) in Group I and $-56.9^\circ$ (range $-70.1$ to $-32.6^\circ$) in Group II. There was no significant difference in the preoperative, postoperative, and last follow-up entire lumbar lordotic angle between the two groups. Decrement of the entire lumbar lordotic angle between the postoperative period and the last follow-up was $6.2^\circ$ in Group I and $3.0^\circ$ in Group II. The mean preoperative segmental lordotic angle of the index level was $-15.1^\circ$ (range $-26.7$ to $8.8^\circ$) in Group I and $-13.3^\circ$ (range $-27.4$ to $2.1^\circ$) in Group II. The mean postoperative segmental lordotic angle of the index level was $-24.2^\circ$ (range $-42.4$ to $-15.0^\circ$) in Group I and $-23.2^\circ$ (range $-38.2$ to $-8.2^\circ$) in Group II. The mean segmental lordotic angle of the index level was $-21.9^\circ$ (range $-38.0$ to $-4.6^\circ$) in Group I and $-21.2^\circ$ (range $-34.5$ to $-5.7^\circ$) in Group II at last follow-up. There was no significant difference in the preoperative, postoperative, and last follow-up segmental lordotic angle of the index level between the groups. The decrement of the segmental lordotic angle at the index level between the postoperative period and the last follow-up was $3.3^\circ$ in Group I and $2.0^\circ$ in Group II. There was no significant intergroup difference in the decrement of the segmental lordotic angle at the index level. The mean percentage of cage subsidence was $19.6\%$ (range $0.2$–$51.0\%$) in Group I and $5.2\%$ (range $1.0$–$15.3\%$) in Group II. The mean percentage of cage subsidence was significantly higher in Group I than in Group II ($p = 0.001$, independent t-test). However, in 2 patients we observed a more than $10\%$ loss of preoperative disc height at final follow-up, despite PMMA augmentation, and in both patients the augmented PMMA cement mass was located far from the endplate. The mean percentage of VB collapse was $10.7\%$ (range $6.1$–$22.7\%$) in Group I and $3.9\%$ (range $0.4$–$9.2\%$) in Group II. The mean percentage of VB collapse was significantly higher in Group I than in Group II ($p < 0.001$, independent t-test) (Figs. 4 and 5). The incidence of radiographic ASD was $66.7\%$ (16 of 24 patients) in Group I and $68.2\%$ (15 of 22 patients) in Group II. There was no significant difference in the incidence of radiographic ASD between the groups. The osteoarthritis grade of the facet joint showed high reliability (Table 5), and the same reliability was shown by the interobserver reliability test. The data sets that exhibited the highest reliability coefficients were used for the data analysis (the first measurement of Observer 1 was used).

**Complications**

In 8 patients (5 in Group I and 3 in Group II) an adverse event developed during perioperative period. Four patients had sympathetic dysfunction with temperature variation in the affected lower extremity. This is clinically benign and requires nothing more than reassurance of the patients. One patients required reclosure of dehiscent abdominal wound. A case of pulmonary effusion was detected on postoperative chest radiography and the patient had mild respiratory insufficiency. After a few days of diuretic therapy, symptom and radiological finding were much improved. Two patients had persistent ileus more
than 3 days after surgery. Ileus was resolved after a few days of conservative treatment without sequelae. With regard to anterior PMMA augmentation, no complications, such as cement leakage, pulmonary embolism, or infection, occurred. There was 1 case of nonunion and 3 cases of screw migration in Group I, but none resulted in implant failure.

Discussion

The number of elderly patients requiring lumbar fusion surgery is rapidly increasing with the dramatic increase of life expectancy in recent years. Although instrumented LIF has yielded favorable clinical and radiological outcomes for such patients, the major concerns are osteoporosis-related problems, such as screw loosening, screw pullout, cage subsidence, and fusion failure. Augmentation of PSF with PMMA has been performed to overcome these problems. Because the pullout strength of the screw pitch is decreased by the loosened quality and quantity of cancellous bone, fixation loosening is likely to happen in patients with osteoporosis. Many reports in cadaveric and in vitro studies have focused on the efficacy of PMMA augmentation of PSF; these reports were generally favorable in terms of biomechanical and radiological outcomes. Chang et al. reported satisfactory results for the usability of PMMA augmentation with PSF in patients with osteoporosis.

In the majority of the previous studies on PMMA bone cement augmentation, cement was injected using a vertebroplasty needle posteriorly through the pedicle before pedicle screw insertion to create firm cement bonding between the pedicle screw and cancellous bone. Unlike in posterior LIF, a single large lordotic cage was inserted into the center of the disc space during instrumented ALIF, which significantly, and sometimes excessively, increased the intervertebral disc height and segmental lordotic angle. Therefore, the possibility of endplate injury and resultant cage subsidence was one of the concerns associated with instrumented ALIF in patients with osteoporosis. Tan et al. reported that cement augmentation decreased the rate of cage subsidence in cadaveric specimens because it increased the interface strength between the interbody device and VB. Heini suggested cement injection as one of the methods that decrease cage subsidence in patients with osteoporosis. In the present study, to prevent cage subsidence, PMMA was injected anteriorly into the center of the VB before cage insertion. The mean degree of cage subsidence was significantly lower in the group of patients with instrumented ALIF augmented with PMMA compared with the nonaugmented group. However, in 2 patients we observed a more than 10% loss of preoperative disc height at final follow-up, despite PMMA augmentation, and in both patients the augmented PMMA mass was located far from the endplate. Therefore, it is preferable to locate the cement mass near the endplate to prevent cage subsidence.

Many reports have suggested the advantages of prophylactic cement augmentation in osteoporotic patients. The major advantages of prophylactic cement augmentation over vertebroplasty for osteoporotic compression fractures are that it is better for restoring stiffness, there is less cement leakage, and it is good for the maintenance of spinal alignment. In the present study, the mean decrease in VB height at the index level was significantly lower in the PMMA-augmented group than the nonaugmented group, which suggests that prophylactic anterior PMMA augmentation reduced the risk of compression fracture at the index level.

With anterior PMMA augmentation, cement bonding between the pedicle screw and cancellous bone was not achieved, because the cement had already solidified at the PSF site. However, there was no screw failure in the anterior PMMA-augmented group, whereas several cases of screw migration were observed in the nonaugmented group. It seemed that a relatively firm hold could be achieved since the hard cement mass located in the center of the VB may act as a fulcrum to the pedicle screw on both sides.

In patients with osteoporosis, a compression fracture decreases VB height. In addition, decreased pedicle screw pullout strength due to osteoporosis could result in a fixation loosening or nonunion. As a result, a decrease of segmental or entire lumbar lordotic angle could occur, which might cause sagittal imbalance during long-term
In instrumented ALIF with vertebroplasty

follow-up. In the present study, there was a tendency of the entire lumbar lordotic angle to decrease in the non-augmented group. To determine the effect of anterior PMMA augmentation on sagittal balance after instrumented ALIF, further long-term follow-up studies are necessary.

Although there has been no report concerning the influence of anterior PMMA augmentation on osseous fusion, many spine surgeons assume that cement injection may partially block the intravertebral blood circulation and influence fusion. In the present study, solid fusion was achieved in all patients in both groups, and there was no patient with nonunion. Therefore, anterior cement augmentation itself did not increase the nonunion rate in instrumented ALIF.

Although it is considered to be controversial, there have been many studies on the clinical and biomechanical effects of vertebroplasty for both the adjacent segment and index level in the osteoporotic spine. The authors of long-term clinical studies have reported that the failure rate of the VB adjacent to the index level was much higher than in the control group in which vertebroplasty was not performed.15,30,32 The authors of in vitro studies have also reported that vertebroplasty distorted the structural response and decreased the geometric restoration for load.1 Furthermore, vertebroplasty led to the development of adjacent compression fractures by decreasing the failure load of the adjacent VB.2,4,24,34 On the other hand, Oakland et al.22 reported that prophylactic vertebroplasty did not lead to adjacent VB fracture with normal physiological activity in a cadaveric study. In addition, in their clinical analysis of cement augmentation of the pedicle screw Chang et al.7 reported only 1 case of adjacent VB compression fracture 1 year after surgery in 41 patients. In the present study, there was no significant difference in the decrease of the adjacent VB height in either group. There was also no significant difference in the prevalence of radiographic ASD.

Cement leakage is the most common and troublesome complication in vertebroplasty for compression fracture. One group reported a considerable rate of cement leakage (up to 26.2%) during posterior cement augmentation with PSF.4 However, in the present study there was no cement leakage during anterior cement augmentation, even with a large PMMA injection. There was no other complication related to anterior PMMA augmentation. Therefore, this method appears to be a safe and effective augmentation method for the osteoporotic VB.

The limitations of this study are the possible intrinsic flaw of the retrospective study and small sample size. The follow-up period was sufficient for evaluating the change of index level including cage subsidence, collapse of the VB, and union rate, but it was not sufficient for evaluating the ASD, late effect of cage subsidence on sagittal imbalance, and clinical outcomes. Therefore, longer follow-up is necessary. Regarding union rate, the present study used ALIF with a mixture of local autologous bone, allograft bone chips, and demineralized bone matrix. Therefore, the effect of ALIF and demineralized bone matrix on the union rate must be considered. To evaluate the advantages and limitations of anterior PMMA bone cement augmentation, a comparative study with conventional cement augmentation used in the posterior approach should be conducted.

Conclusions

Anterior PMMA augmentation with instrumented ALIF for patients with osteoporosis is a useful method that could minimize cage subsidence and VB collapse. In addition, PMMA augmentation did not increase the nonunion rate or prevalence of ASD. There was no statistical difference of clinical outcomes in between the ALIF-alone group and ALIF with PMMA group.

Disclosure

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