Video-Assisted Thoracoscopic Surgery for Re-Collapse of Vertebrae after Percutaneous Vertebral Augmentation (PVA)

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Abstract:

Introduction: Due to the increase in osteoporosis accompanying the aging society in Japan, osteoporotic vertebral fractures (OVFs) are increasing. Percutaneous vertebral augmentation (PVA) has been widely used for OVFs because it reduces pain immediately with less invasiveness. Re-collapse of vertebral body after PVA is a rare, but important, complication. Once the re-collapse has occurred, patients should undergo an additional invasive salvage surgery.

Methods: We treated 5 patients with re-collapse after PVA in our hospital. For re-collapse after PVA, we performed anterior column reconstruction with video-assisted thoracoscopic surgery (VATS), posterior fixation with percutaneous pedicle screws (PPSs) and minimally invasive spine stabilization (MISt).

Results: The mean postoperative follow-up was at 62.8 months. At the final follow-up, the patients were free of low back pain, and bony union was achieved in all cases. The postoperative correction loss was 6 degrees. Perioperative complications included aspiration pneumonia in one patient and bone fracture of an adjacent vertebral body in two patients. There were no reoperation cases.

Conclusions: We perform minimally invasive combined anterior and posterior surgery with VATS for re-collapse after PVA. This procedure is useful in elderly patients with less reserve capacity.

Keywords:

Video-Assisted Thoracoscopic Surgery (VATS), re-collapse, Percutaneous vertebral augmentation (PVA), Osteoporotic vertebral fractures (OVFs), Minimally Invasive Spine Stabilization (MISt), percutaneous vertebroplasty (PVP), balloon kyphoplasty (BKP)

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Introduction

The increase in osteoporosis associated with the aging society in Japan has attracted attention as an important social and medical problem. Osteoporotic vertebral fractures (OVFs) are the most frequent osteoporotic fractures. Most patients with OVFs can be treated conservatively. However, if patients develop pseudoarthrosis, they might have severe low back pain or delayed neuropathy, which may affect their quality of life (QOL). Percutaneous vertebral augmentation (PVA), like percutaneous vertebroplasty (PVP) and balloon kyphoplasty (BKP), has been used widely for OVFs because it reduces pain immediately with less invasiveness[1-3]. However, PVA is associated with various complications[4-7]. Early complications after PVA include bleeding, cement or artificial bone leakage, and infection. Adjacent vertebral fracture is a common delayed complication. On the other hand, re-collapse of the vertebral body after PVA, due to trauma or other causes, is often considered clinically significant, but there are only a few reports on this complication[8,9]. Once the re-collapse has occurred, patients may require an additional invasive salvage surgery because of progressive local kyphosis and spinal cord compression. The procedure of salvage of this re-collapse is controversial, but candidate treatments include re-vertebroplasty[10,11], anterior reconstruction[12,13], and combined anterior and posterior surgery[12]. However, conventional anterior reconstruction is highly invasive for elderly patients.

In recent years, minimally invasive techniques are highly prevalent and have been used for anterior surgery of the thoracolumbar junction region[14]. For example, lateral lumbar interbody fusion (LLIF)[15] and video-assisted thoracoscopic

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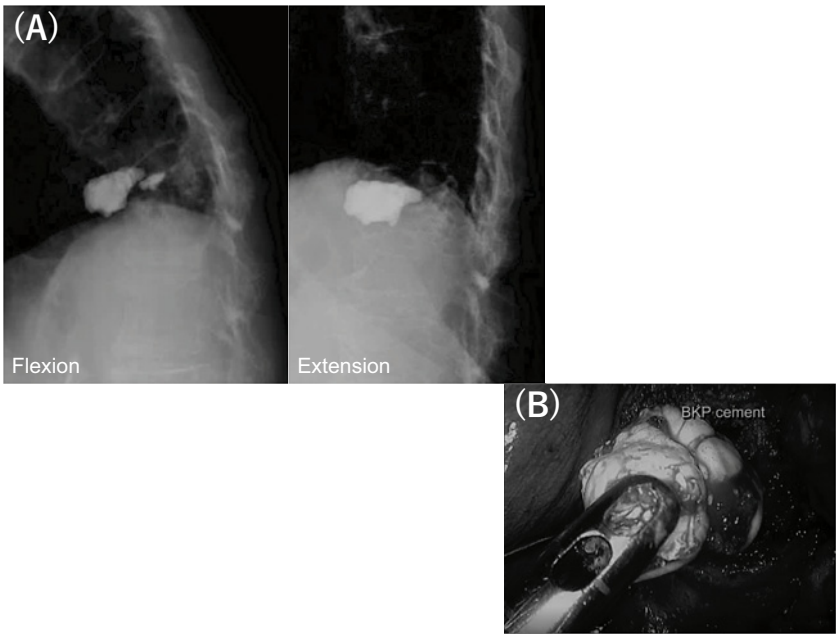

Figure 1. A 78-year-old woman with a T12 BKP (balloon kyphoplasty) re-collapse.
(A) Flexion-extension radiograph showing the re-collapse of the T12 vertebra and cement fragmentation.
(B) The cement fragment was removed easily.

surgery (VATS) using a thoracoscope[16-20] have been described. In our hospital, we perform anterior reconstruction with VATS and posterior fixation with percutaneous pedicle screws (PPSs) and minimally invasive spine stabilization (MISt). This paper describes the usefulness of minimally invasive combined anterior and posterior surgery using VATS for re-collapse after PVA.

Materials and Methods

We treated five patients with re-collapse after PVA in our hospital from September 2012 to April 2016. There were two males and three females with a mean age of 75 years. The mean postoperative follow-up was at 62.8 months (range: 38-89 months). Of these patients, three developed re-collapse after percutaneous vertebroplasty (PVP) and two after balloon kyphoplasty (BKP). Four patients had their first augmentation surgery at our hospital and one patient at another institution. Three patients experienced re-collapse after falling. In one case, the posterior implant was removed after infection; after that, the anterior strut failed. The other patient experienced a gradual re-collapse due to reconstruction with artificial bone alone. The mean duration from the first augmentation surgery to the second VATS surgery was 8.8 months (range: 3-19 months). All patients were treated for osteoporosis between the first augmentation surgery and re-collapse. The vertebrae level of re-collapse was the thoracolumbar junction region in all patients: T12 in four patients and L1 in one patient (Table 1).

We performed anterior reconstruction using VATS and posterior fixation with PPSs and MISt.

All procedures were performed with the patients under general endotracheal anesthesia using a double-lumen tube to collapse the ipsilateral lung. All patients were placed in a left lateral decubitus position. Four separate skin incisions were marked over the intercostal spaces to insert the thoracoscopic working portals. A small incision of about 4 cm was made between the ribs on the left chest, just above the affected vertebral body, to create the main working port. Subsequent portals were positioned: A port for the camera on the head side and a port for retract and suction on the ventral side in separate intercostal spaces. A rigid endoscope with a 30°angle scope was placed through a camera port. A guide needle was placed at the posterior edge of the craniocaudal vertebral body to the target. After radiologic confirmation of the correct level of the vertebral body or intervertebral disc space, the parietal pleura was divided using monopolar electrocautery. The segmental vertebral vessels were identified and cauterized using monopolar electrocautery or ligation. Resection of the affected vertebral body was basically the same as open surgery. Bone and disk removal were restricted to the extent of implant insertion, so stability was not compromised. After the retractor was placed in the main working port, the intercostal space was expanded, taking care to spread the ribs so they did not break, and the implant was inserted. We also removed the cement fragment and artificial bone materials. The cement could be removed easily because of fragmentation (Fig. 1). If fusion were required, bone could be harvested from the ribs, iliac crest, or fibula. All cases in our hospital used allogeneic bone graft.

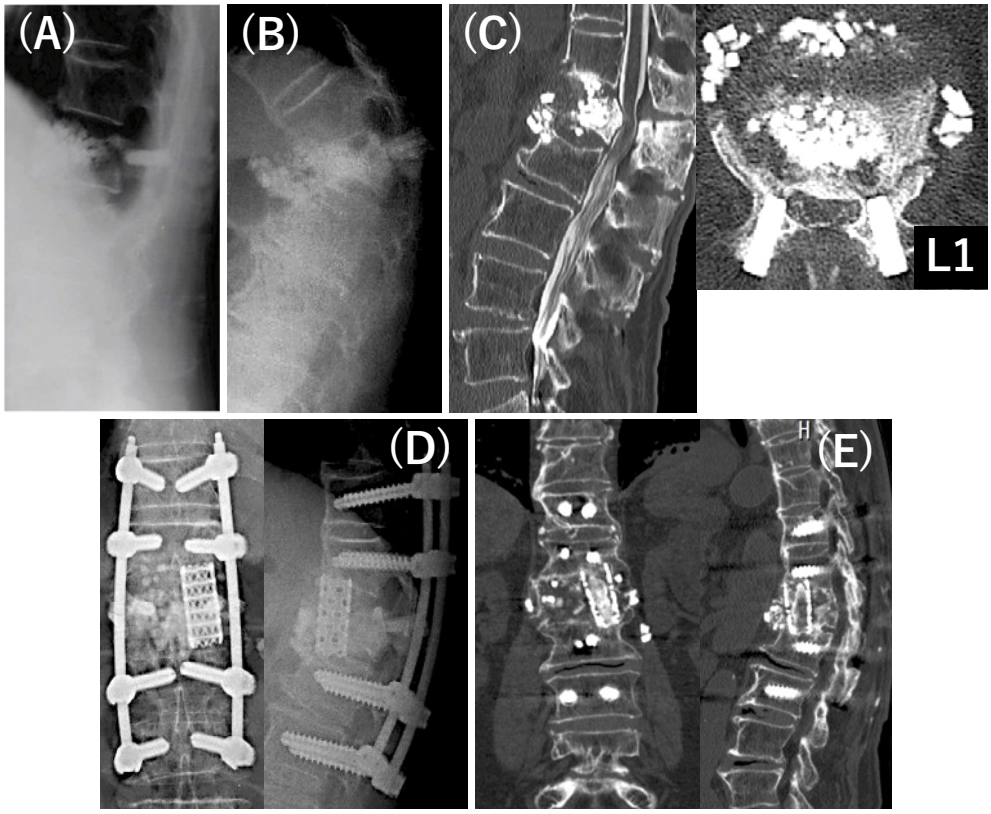

Figure 2. Case 1: A 76-year-old man with a L1 PVP re-collapse.
Radiographs showing the first augmentation surgery (A).
One years later, L1 vertebra was gradually collapsed due to reconstruction with artificial bone alone (B).
CT image showing collapsed L1 vertebra and scattered artificial bone (C).
Radiographs after surgery (D).
CT image at 89 months after surgery; there is a subsidence of the cage, but bone union has been achieved (E).

The anterior instrumentation was placed with allogeneic bone. When surgery was finished, the chest tubes were placed and set under water-sealed suction. The posterior fixation was not corrected and was fixed by the MISt procedure using PPSs.

The correlation of outcome with the following items was evaluated: (1) operative time; (2) intraoperative blood loss; (3) hospital stay; (4) kyphosis angle before and after surgery; (5) complications.

Results

The mean operative time was 155 minutes (range: 120-231 minutes) for anterior reconstruction and 149 minutes (range: 90-194 minutes) for posterior fixation. The mean intraoperative blood loss was 138 g (range: 10-400 g) during anterior reconstruction and 71 g (range: 10-150 g) during posterior fixation. The mean time to recovery was four days (range: 3-6 days). The mean follow-up period from the second VATS surgery to the final follow-up period was 62.8 months (range: 38-89 months). The preoperative kyphosis angle was 48 degrees (33-62°), the postoperative kyphosis angle was 20° (5-29°), and the correction angle required during surgery was 28 degrees (4-47°). The postoperative correction loss was 6 degrees (2-10°) (Table 2). At the final follow-up, the patients were free of low back pain, and bony union was achieved in all cases. Perioperative complications included aspiration pneumonia in one patient and bone fracture of an adjacent vertebral body in two patients. There were no cases of reoperation. Four patients are still able to visit the hospital, and one patient died 38 months after the operation.

The limitations of this paper are the small number of cases and the inability to specifically evaluate ADL.

Case presentation

Case 1: A 76-year-old man (Fig. 2)

PVP was performed for an L1 osteoporotic compression fracture. The patient's low back pain was relieved. One years after surgery, L1 vertebra was gradually collapsed due to reconstruction with artificial bone alone. Anterior spinal reconstruction with VATS and posterior fixation from T11 to L3 with MISt was performed. The operative time was 231 minutes for anterior fixation and 150 minutes for posterior

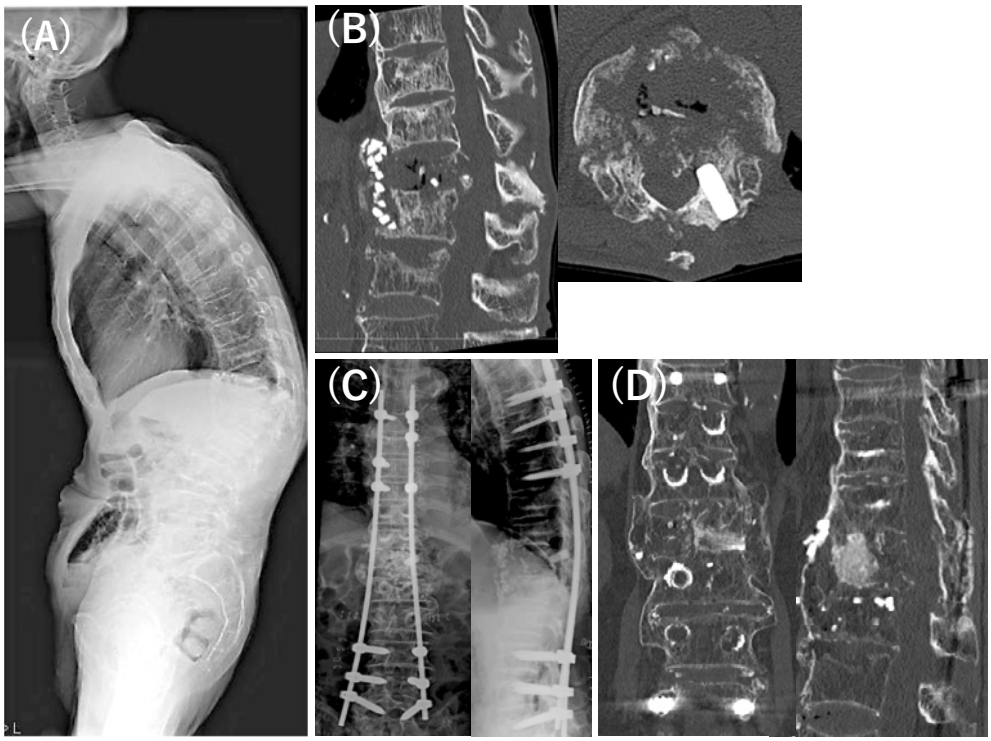

Figure 3. Case 5: A 83-year-old man with a T12 PVP re-collapse.
Radiograph showing the whole spine shows kyphosis after re-collapse (A).
19 months later after the first augmentation surgery, the CT image shows collapsed T12 vertebra and scattered artificial bone (B).
Radiographs after surgery (C).
CT image at 68 months after surgery, bone union has been achieved at the T11-L1 levels (D).

fixation. The intraoperative blood loss was 55 g. Computerized tomography (CT) 89 months after surgery showed mild cage subsidence, but bone union was achieved with a slight correction loss (6°).

Case 5: A 83-year-old man (Fig. 3)

PVP and posterior fixation were performed at another hospital for L1 osteoporotic compression fractures. All posterior implants were removed due to infection. After that, the spine gradually deformed kyphosis, and the back pain worsened. Nineteen months after the first augmentation surgery, anterior spinal reconstruction with VATS, and posterior fixation from T6 to L5 with MISt was performed. Anterior reconstruction was performed using allogeneic bone graft only. The operative time was 129 minutes for anterior fixation and 191 minutes for posterior fixation. The intraoperative blood loss was 550 g. CT 68 months after surgery showed bone union with a slight correction loss (2°).

Discussion

In Japan, osteoporosis is increasing with the super-aging society, and it is becoming a social problem. The number of osteoporosis patients is already estimated to be more than 12 million.

OVFs are the most frequent osteoporotic fractures.

In general, most OVFs are often cured by conservative treatment, such as a corset or drug treatment. However, pseudoarthrosis cases, in which bone fusion is not completed after a vertebral fracture, may be problematic. Approximately 10-30% of patients experience pseudoarthrosis after OVFs[21,22]. Elderly patients with pseudoarthrosis can have decreased activities of daily living, resulting in a substantial negative impact on their QOL. Percutaneous vertebroplasty (PVP) was introduced by Galibert[23] in 1987. It was reported that using PVP to treat osteoporotic spinal compression fractures yields excellent results[24]. Subsequently, BKP was described by Reiley[1] in 2001. PVA procedures for OVFs have been used widely in recent years because they are minimally invasive and allow elderly patients to recover earlier.

Complications associated with PVA include bleeding, infection, cement or artificial bone leakage, and fracture of adjacent vertebral bodies[4-7]. But there are only a few reports[8,9] on re-collapse after PVA or treatment for this failure. Once the vertebral body after PVA is damaged, progressive kyphosis, and severe instability can occur. Therefore, it is important for patients to receive educational training after PVA, along with postoperative treatment for osteoporosis and close follow-up[25]. The incidence of re-collapse after PVA is reported to be approximately 0.56-3.21%[8,11]. Re-collapse of the vertebral body treated by PVA could be caused by osteonecrosis of the vertebral body, excessive ce-

Table 1. Clinical Characteristics of 5 Patients with Re-Collapse of Vertebrae who Underwent Video-Assisted Thoracoscopic Surgery (VATS).

Patient number	Age (years)	Gender	First augmentation surgery	Location of first augmentation surgery	Levels	Causes	First surgery → Second surgery (months)	Follow up period (months)	Osteoporosis treatment
1	76	M	PVP	Our hospital	L1	Unknown	12	71	○
2	68	F	BKP	Our hospital	T12	Fall	7	57	○
3	78	F	BKP	Our hospital	T12	Fall	3	36	○
4	73	F	PVP	Our hospital	T12	Fall	3	53	○
5	83	M	PVP	Another institution	T12	Infection	19	35	○

Table 2. Operative Characteristics of 5 Patients with Re-Collapse of Vertebrae who Underwent Video-Assisted Thoracoscopic Surgery (VATS).

Patient number	Anterior operative time (min)	Posterior operative time (min)	Anterior reconstruction	Anterior EBL (ml)	Posterior EBL (ml)	Hospital stay (days)	Chest tube detention (days)	Complications	Kyphosis angle (pre op)	Kyphosis angle (post op)	Kyphosis angle (Final)	Correction loss (°)
1	231	150	Cage	0	55	29	3		62	23	29	6
2	135	194	Cage	170	100	34	3		49	28	33	5
3	120	90	Cage	50	0	30	3	Adjacent fracture	42	15	22	7
4	161	121	Cage	70	50	17	2	Adjacent fracture	33	29	39	10
5	129	191	Allogeneic bone graft only	400	150	65	2	Aspiration pneumonia	52	5	7	2

EBL = estimated blood loss during operation

ment use, delayed spondylodiscitis, or excessive angle correction during vertebroplasty[12,26].

The standard treatment for re-collapse after PVA has not been established, but re-vertebroplasty[10,11] and anterior reconstruction[12,13], and combined anterior and posterior surgery[12] have been reported as candidate treatments. Reconstruction of the collapsed vertebral body and preservation of the posterior ligaments and muscles are very important for salvage procedures. Re-vertebroplasty is technically difficult and associated with higher risk[10]. The most reasonable procedure for the damaged anterior column of the vertebral body is anterior reconstruction, but this procedure can be problematic in elderly patients because it is highly invasive. Nagoshi[12] and Miyagi[13] reported their experiences with anterior surgery to remove cement and anterior reconstruction for re-collapse after PVA with favorable outcomes. They also noted that preservation of the ligaments and muscles that stabilize the posterior spine is important[13].

Minimally invasive procedures have been used recently in anterior surgery for the thoracolumbar junction region: VATS, using a thoracoscope, and LLIF. Mack[27] began performing thoracoscopic surgery for the spine in 1993. Subsequently, Rosenthal[28] used a thoracoscopic anterior approach for hernia surgery. In 1996, Dickman[29] performed corpectomy. Afterwards, Picetti[30] performed fixation to correct for scoliosis. Beisse[19] reported his experience with anterior fixation for injuries of the thoracolumbar vertebrae.

Advantages of thoracoscopic surgery include 1) less bleeding, 2) no need for rib excision, and 3) large intrathoracic space for surgery. On the other hand, disadvantages include 1) the need for a chest tube due to single-lung ventilation, and 2) a long learning curve. Furthermore, preparations before surgery are very important. Preparations include interviewing the patient about a history of lung disease or pulmonary surgical procedures, such as pneumonectomy, and collaboration with doctors in the thoracic surgery department before surgery in case of lung adherence to adjacent organs. Although LLIF is less invasive, rib excision is necessary in most cases and lateral chest pain can be observed postoperatively. With respect to VATS, thoracotomy is required but an appropriate surgical field is possible without rib excision[31]. In addition, VATS allows reconstruction of the anterior column and faster improvement in postoperative respiratory function. And MISt with PPSs results in much less invasive posterior column reconstruction, and preservation of the ligaments and muscles, allowing for combined anterior, and posterior combined surgery for the elderly.

We use VATS for anterior column reconstruction, and posterior fixation with MISt to preserve the posterior complex. This procedure is useful in elderly patients with less reserve capacity.

The limitations of this study are the small number of cases and the inability to evaluate HDQOL.

Conclusions

PVA for OVFs is a minimally invasive therapeutic procedure and allows elderly patients to recover earlier. Re-collapse of vertebral body after PVA is an important complication, and surgeons should be careful. Once the vertebral

body after PVA is damaged, patients may require additional invasive salvage surgery because of progressive local kyphosis and spinal cord compression. For re-collapse after PVA, we performed anterior column reconstruction with VATS, and posterior fixation with MISt. This procedure is useful in elderly patients with less reserve capacity.

Conflicts of Interest: The authors declare that there are no relevant conflicts of interest.

Ethical Approval: N/A

Author Contributions: KN wrote and prepared the manuscript, and all the authors participated in the study design. All authors have read, reviewed, and approved the article.

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