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# Open Surgery for Osteoporotic Compression Fracture Within One Month of Single Level Balloon Kyphoplasty

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## ABSTRACT

**Objective:** This study aimed to analyze the reasons for open surgery performed within one month of balloon kyphoplasty (BKP) for osteoporotic compression fractures.
**Methods:** This study included 15 patients treated with open surgery within one month of BKP in our institution from 2013 to 2020. Among them, 10 patients underwent BKP in our institution and 5 patients were transferred because of adverse events after undergoing BKP at another hospital. Clinical findings including main indications, neurological deficits, and clinical course were analyzed.
**Results:** All patients were followed up for at least 12 months after surgery (average time 15.5 months, range 12–39 months). Their mean age was 73.7 years and the mean T-score of the spine on bone densitometry was −3.35. The main reasons for open surgery included dislodgement of the cement mass or spinal instability (7 cases, 47%), neural injury due to cement leakage (3 cases, 20%), and spinal cord injury caused by a puncture mistake (3 cases, 20%). Two patients developed acute spinal subdural hematoma, and spinal epidural fluid was pushed out at the back edge of the vertebral body following BKP without signs of major cement leakage into the spinal canal. At the final follow-up, 7 patients with cement mass dislodgement showed complete improvement of related symptoms after posterior fusion with screw fixation. Among the 8 patients with neural injury, 6 improved; however, 2 remained at the same American Spinal Injury Association level.
**Conclusion:** The main reasons for open surgery were cement mass dislodgement and neural injury caused by puncture errors or cement leakage into the spinal canal. It should be noted that proper selection of cases, detailed imaging evaluation, and optimal surgical techniques are key to reducing open surgery after BKP.

**Keywords:** Surgery; Kyphoplasty

## INTRODUCTION

Balloon kyphoplasty (BKP), as a modification of percutaneous vertebroplasty, has theoretical advantages including focal kyphosis correction and reduced cement leakage because of lower cement injection pressure and increased viscosity.[2)]

Despite the theoretical advantages of BKP, it is not free from complications.[13] Potential complications of BKP include cement leakage into the spinal canal with subsequent spinal cord injury (SCI), infection, hematoma formation, failure to relieve pain and adjacent vertebral fractures. Moreover, BKP sometimes fails to improve patients' outcomes, requiring open surgery, using anterior or posterior instrumentation.[12]

So far, however, there have been few reports on open surgery after failed BKP. Therefore, we analyzed the main causes of open surgery after BKP and investigated the clinical outcome of open surgery following BKP in the present study.

## MATERIALS AND METHODS

This study included 15 patients (male:female=6:9) who underwent open surgery within one month after BKP in our institute from 2013 to 2020.

A total of 151 consequent patients who underwent single-level BKP in our institute were eligible and 10 patients underwent open surgery within 1 month during the same period. In addition, 5 patients were transferred to our hospital for surgery following BKP at the same period (**FIGURE 1**).

The inclusion criteria were: 1) Patients who underwent open surgery within one month following single-level BKP; 2) Patients who underwent BKP for osteoporotic compression fracture (OCF) (mean T-score on dual-energy X-ray absorptiometry at lumbar spine <−2.5); and 3) Patients who had no symptoms of SCI or nerve root injury (NRI) before BKP.

Patients who underwent BKP for multiple compression fractures, malignant metastasis and significant infection as the cause of surgery were excluded from this study. American Spinal Injury Association (ASIA) assessment was used to document sensory and motor impairments in 8 patients with SCI or NRI.[5]

Clinical findings including main causes of open surgery, neurologic deficits and clinical course were analyzed.

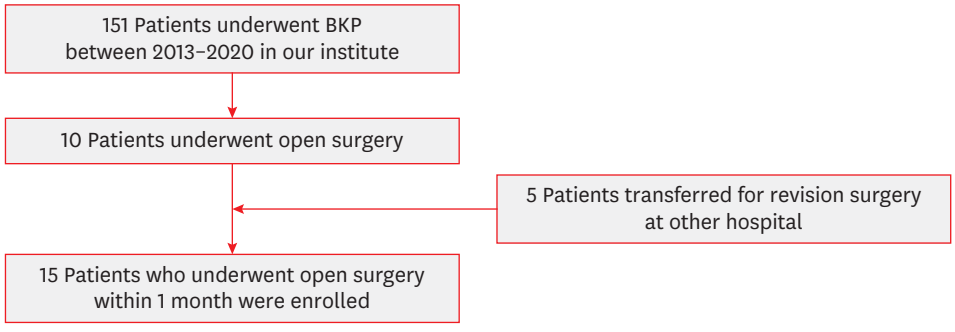


**FIGURE 1.** Flow chart of study design.
BKP: balloon kyphoplasty.


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## RESULTS

The 15 patients were followed up for at least 12 months with an average time of 15.5 months (range: 12–39 months) after surgery. The mean age of the patients was 73.7 years with a range from 62 to 82 and the mean T-score of the spine on bone densitometry was −3.35. All BKPs had been performed under local anesthesia.

Open surgery was performed for neurological deficits or uncontrolled back pain after BKP within one month due to cement dislodgement, cement leakage into the spinal canal, improper needle insertion, spinal epidural fluid and acute spinal subdural hematoma (SDH) (**TABLE 1**).

Transpedicular screw fixation with bone grafting after decortication of the posterolateral fusion bed, a mixture of local bone chips was performed in 7 patients for cement dislodgement (**FIGURE 2**). All 7 patients with cement dislodgement had the presence of an intravertebral cleft (IVC) or increased angular motion on dynamic radiographs. Complete relief of back pain was achieved after surgery in all 7 patients with cement dislodgement. Three patients had cement leakage to the spinal canal causing SCI or NRI. Three patients had SCI because of malposition of the puncture needle and the spinal cord was directly damaged (**FIGURE 3**). Posterior lumbar interbody fusion (PLIF) following removal of leaked cement or decompressive laminectomy without instrumentation was performed in 6 patients. One patient who had IVC showed acute paraparesis caused by the spinal epidural fluid at the back edge of the vertebra without cement dislodgement or cement leakage underwent bone cement augmented percutaneous screw fixation and showed complete recovery of paraparesis. One patient developed an acute spinal SDH without signs of cement leakage to the spinal canal. Due to the acute motor deficit in the lower limbs, emergent decompressive laminectomy at the level of BKP was performed.

Six out of 8 patients who had SCI or NRI due to cement leakage, acute spinal SDH, spinal epidural fluid or puncture mistake during BKP showed recovery of SCI or NRI in terms of ASIA-evaluated level. However, the other 2 patients with SCI directly damaged by a puncture mistake remained at the same ASIA-evaluated level (**TABLE 2**).

**TABLE 1.** Characteristics of enrolled patients

| Case | Age/sex | Level | BMD | Symptom | Risk factors | Causes | Surgery |
|---|---|---|---|---|---|---|---|
| 1 | 72/F | L3 | −3.2 | Back pain | IVC | Cement dislodgement | Posterior fusion |
| 2 | 82/F | L2 | −2.9 | Paraparesis | - | Malposition of needle | Laminectomy |
| 3 | 75/M | L1 | −2.8 | Paraparesis | IVC | Spinal epidural fluid compressing cord | Screw fixation |
| 4 | 79/F | T12 | −3.5 | Back pain | IVC | Cement dislodgement | Posterior fusion |
| 5 | 62/F | T12 | −3.0 | Back pain | IVC | Cement dislodgement | Posterior fusion |
| 6 | 80/F | L1 | −3.2 | Back pain | IVC | Cement dislodgement | Posterior fusion |
| 7 | 72/M | L2 | −2.8 | Back pain | IVC | Cement dislodgement | Posterior fusion |
| 8 | 77/M | L2 | −2.9 | Paraparesis | - | Malposition of needle | Laminectomy |
| 9 | 71/M | T10 | −3.2 | Radiating pain | - | Cement leakage to Thoracic vertebral canal | Laminectomy |
| 10 | 68/F | L1 | −3.9 | Paraparesis | - | Malposition of needle | Laminectomy |
| 11 | 69/F | L2 | −3.7 | Back pain | IVC | Cement dislodgement | Posterior fusion |
| 12 | 78/F | L1 | −3.4 | Paraparesis | - | Cement leakage to nerve root canal | Laminectomy |
| 13 | 67/F | L2 | −2.8 | Radiating pain | - | Cement leakage to nerve root canal | PLIF |
| 14 | 80/M | T12 | −4.0 | Back pain | IVC | Cement dislodgement | Posterior fusion |
| 15 | 74/M | L2 | −3.0 | Paraparesis | - | Spinal SDH | Laminectomy |

BMD: bone marrow densitometry, IVC: intravertebral cleft, SDH: subdural hematoma, PLIF: posterior lumbar interbody fusion.


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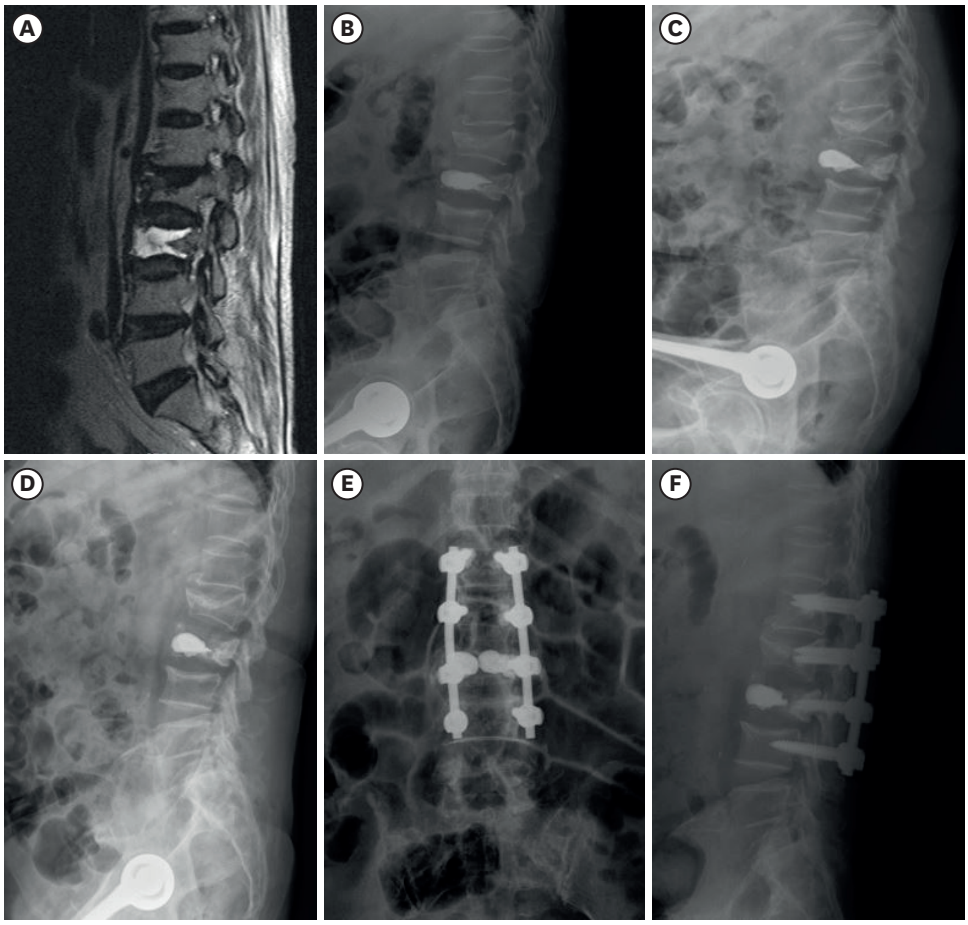


**FIGURE 2.** A 72-year-old female with osteoporotic vertebral fracture of L3.
(A) T2-weighted magnetic resonance image reveals acute compression fracture at L3 with a fluid signal. (B) Lateral simple radiograph shows good filling of bone cement after BKP. (C, D) Flexion and extension radiographs obtained at 2 weeks after BKP reveal dislodgement of cement. (E, F) Simple radiographs taken at 14 months after open posterior fusion with screw fixation show good surgical stabilization.
BKP: balloon kyphoplasty.

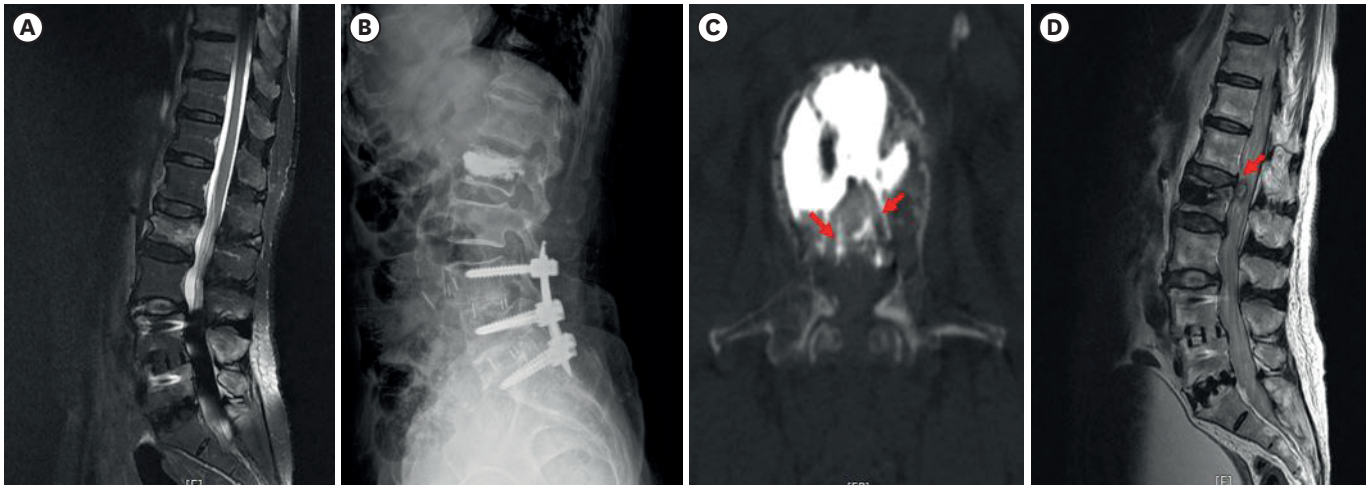


**FIGURE 3.** A 82-year-old female patient with an osteoporotic compression fracture of L2.
Lateral simple radiograph shows osteoporotic compression fracture of L2. (A) Preoperative fat-suppressed sagittal magnetic resonance image shows an acute compression fracture at L2. (B) Lateral simple radiograph shows good filling of bone cement. (C) Axial computed tomography scan shows the medial trajectory of puncture needles (arrows). (D) Preoperative fat-suppressed sagittal magnetic resonance image reveals a signal change in the spinal cord (arrow).


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**TABLE 2.** ASIA evaluation or muscle strength of patients

| Case | Time interval between BKP and open surgery (days) | Preoperative ASIA | Final ASIA |
|---|---|---|---|
| 1 | 28 | E | E |
| 2 | 2 | B | B |
| 3 | 24 | C | E |
| 4 | 30 | E | E |
| 5 | 30 | E | E |
| 6 | 21 | E | E |
| 7 | 28 | E | E |
| 8 | 2 | C | C |
| 9 | 25 | D | E |
| 10 | 3 | C | D |
| 11 | 27 | E | E |
| 12 | 28 | D | E |
| 13 | 25 | E | E |
| 14 | 27 | D | E |
| 15 | 8 | C | E |

ASIA: American Spinal Injury Association, BKP: balloon kyphoplasty.

## DISCUSSION

BKP has been shown to proceed with immediate pain relief for geriatric patients with OCFs refractory to conservative treatments.[15] Despite its higher costs, BKP has the advantages of deformity correction and decreased cement leaks compared with percutaneous vertebroplasty, which requires cement injection at higher pressure.[8] However, it is not free of complications, and serious adverse events requiring open surgery may occur after BKP. Most complications after BKP are known to be directly related to cement extravasation or cement leaks causing SCI or NRI, in which case open surgery is often used to relieve neurological deficits. We discuss the main reasons and the corresponding prevention measures. Knowledge of this complication and its physiology are important in ensuring that the necessary precautions are taken when performing BKP for OCFs.

### Cement dislodgement and its prevention

In this study, cement dislodgement accounted for the main adverse events. If cement dislodgement develops after BKP, and becomes symptomatic, posterior instrumentation and bone grafting surgery might be required.

Wang et al.[13] reported that the injection of viscous cement with low pressure decreases the penetration of the cement into the microstructure of cancellous bone. It would be expected to have far less interdigitation with the surrounding hollow trabecular space than partially intact trabecular bone in avascular necrosis. Heo et al.[3] asserted that bone cement augmentation procedure alone for treating Kummell's disease is associated with recurrent collapse as well as dislodged or fragmented bone cement causing poor prognosis after percutaneous vertebroplasty. Lee et al.[6] also reported that restored vertebral heights and corrected kyphotic angles were reaggravated, suggesting that vertebral osteonecrosis progresses after a bone cement augmentation procedure alone.

They concluded that stabilization by instrumentation should be considered a treatment option for avascular necrosis even without neurologic deficits. The greater angular motion might reflect the breakage or dysfunction of the anterior spinal element, including the anterior longitudinal ligament and annulus, which might lead to failure in maintaining the cement with the vertebral body. Anterior dislodgment of cement causes instability and poor clinical outcome.[9]


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Yonezawa et al.[14] reported revision BKP and pediculoplasty using cannulated screws could be an effective technique to stabilize the OCFs with cement dislodgement after failed BKP instead of highly invasive instrumentation surgery. Based on our findings, we do not recommend BKP for Kummell's disease and cement-augmented screw fixation may be effective for these kinds of fractures.

### Cement leakage into the spinal canal

It is well known that BKP is related to a lower cement leak rate than vertebroplasty in OCFs.[11] However, this result should be interpreted cautiously because the occurrence of cement leaks may be multifactorial. In vivo study revealed that injected pressure and the dose are positively correlated with cement leakage rate.[8] Although rare in BKP, serious neurological deteriorations may occur, which are associated with cement leaks compressing the spinal cord or nerve root. Recently, Takahashi et al.[10] reported that a large defect of endplate and split-type fractures might be related to a higher incidence of cement leaks, increasing the risk of open surgery. In our study, 3 patients showed significant spinal cord compression or nerve root canal stenosis caused by cement leaks. Neural damage was mainly caused by mechanical compression, not the burning of cement extravasation. Therefore, removal of cement leaks by PLIF or open decompression surgery was used and patients obtained good neurological function recovery.

### Malposition of the puncture needle

In our study, despite the benefits of BKP, misplaced needle insertion occurred in 3 patients due to the difficulties in the insertion of large gauge trocars into a vertebral body through pedicles.

Due to more serious and irreversible consequences, the malposition of puncture needles and puncture mistakes should receive careful attention. In cases of narrow pedicle width, the entry point of puncture needles should be outside of the pedicle and the angle of the needles should be reduced with special attention. It is important to know that if the puncture needles are located at the midline when the needle is not deep enough, the possibility of neural damage by entering the spinal canal should be suspected.[4]

### SDH

Spinal SDH is a rare complication that developed after a successful BKP. It is believed that a spinal SDH developed after the puncture of the spinal dura mater and that venous blood began to slowly enter the subdural space after this trauma.[1] The role of venous congestion leading to the rupture of the fragile radiculomedullary veins into the subdural space has been proposed as an etiologic pathway of spinal SDH. In our study, one patient complained of acute motor deficit in both lower limbs and the postoperative magnetic resonance imaging confirmed the presence of a collection of SDH. The patient was subjected to an immediate decompressive laminectomy at the level of BKP. No major compression of the thecal sac or epidural bleeding was identified during the decompressive laminectomy.

### Spinal epidural fluid

A spinal epidural fluid or hematoma after BKP is a rare event. In one patient with IVC, a spinal epidural fluid causing spinal cord compression developed. This is based on a connection between IVC and epidural space. The integrity of the posterior cortex is an important consideration for the development of spinal epidural fluid. Oda et al.[7] reported that the pathophysiology is that the epidural fluid including the hemorrhage inside of IVC may be under pressure and be pushed out into the epidural space during motion. Spinal


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epidural fluid can develop even after BKP. Stabilization using percutaneous screw fixation was an effective treatment for spinal epidural fluid.

The main reasons why open surgery was done after BKP in our study were cement dislodgement, cement leakage into the spinal canal and malposition of the puncture needle.

In the case of cement dislodgement, posterior fusion with transpedicular screw fixation was adopted to enhance spinal stability and obtained satisfactory results. However, once spinal cord injuries caused by malposition of puncture needle occurred, there were some cases where neurological deficits remain even after open surgery was performed. Nonetheless, although there is no conclusive evidence to reveal the exact effect of emergent decompressive surgery, we believe that early stabilization using screw fixation or decompressive surgery is beneficial to the recovery of neural function and can improve patients' prognosis. The limitation of our study should be acknowledged with caution. First, since elderly patients have health comorbidities, they may decline conventional surgery and our study may have selection bias. Second, the period of open surgery from BKP was short, within one month. If the duration of open surgery from BKP was prolonged, the number of patients who might undergo open surgery would have increased.

## CONCLUSION

Due to its low invasiveness, BKP is known to be an effective treatment for OCFs in the elderly. However, it sometimes fails to improve patients' outcomes, requiring open surgery. The main causes for worsened neurological symptoms include cement dislodgement, cement leaks into the spinal canal and malposition of the puncture needle. Once the adverse event occurs, we suggest open surgery as soon as possible, which can usually obtain good results after surgery. It should be noted that proper selection of the cases, detailed imaging evaluation, localization accuracy and controlling the depth and angle of the needle are the keys to reducing the need for open surgery after BKP.

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