

# Radiological and clinical effect of balloon kyphoplasty for the management of rheumatoid arthritis patients with osteoporotic vertebral compression fracture

**Ji Guo**

Shanghai University of Traditional Chinese Medicine

**Weifeng Zhai**

Shanghai University of Traditional Chinese Medicine

**Licheng Wei**

Shanghai University of Traditional Chinese Medicine

**Jianpo Zhang**

Shanghai University of Traditional Chinese Medicine

**Lang Jin**

Shanghai University of Traditional Chinese Medicine

**Hao Yan**

Shanghai University of Traditional Chinese Medicine

**Zheng Huang**

Shanghai University of Traditional Chinese Medicine

**Yongwei Jia** (✉ [spinejia@163.com](mailto:spinejia@163.com))

Shanghai University of Traditional Chinese Medicine

---

## Research article

**Keywords:** Rheumatoid osteoarthritis, Osteoporotic vertebral compression fracture, Balloon kyphoplasty, ESR, CRP, bone cement leakage

**Posted Date:** August 5th, 2020

**DOI:** <https://doi.org/10.21203/rs.3.rs-47606/v1>

**License:** © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

---

# Abstract

**Objective:** This study was conducted to investigate the outcome of percutaneous balloon kyphoplasty (KP) for the treatment of osteoporotic vertebral compression fracture(OVCF) in patients with rheumatoid arthritis (RA) and analyze the influence of erythrocyte sedimentation rate (ESR), c-reactive protein (CRP), injected cement volume and duration of taking glucocorticoid on the outcome of KP procedure.

**Methods:** A total of 39 RA patients (63 vertebral bodies) and 38 patients (50 vertebral bodies) without RA received KP management for OVCF. Changes in vertebral compression rate, local kyphotic angle, conditions of bone cement leakage, visual analogue scale (VAS) and Oswestry disability index (ODI) scores were evaluated for radiological and clinical outcomes of KP procedure. In addition, 39 OVCF patients with RA were divided into different groups according to the value of ESR, CRP, injected cement volume and duration of taking glucocorticoid to evaluate their influence on the outcomes of KP procedure.

**Results:** The KP procedure significantly improved the compression rate, local kyphotic angle, VAS and ODI scores in both RA group and control group. The compression rate increased  $11.56\pm 3.8\%$  in RA group which is significantly larger than the control group( $p<0.05$ ). The change of local kyphotic angle in RA group was  $3.77\pm 1.9$ , which is also larger than that in control group( $p<0.05$ ). Whereas, the changes of VAS and ODI scores were not significantly different between the two groups. Besides, radiological and clinical outcomes were not significantly different among the groups of different ESR, CRP, injected cement volume and duration of taking glucocorticoid no matter before or 1 year after the KP procedure, but 44% RA patients who take glucocorticoid for over 10 years had cement leakage after the KP procedure which is significantly higher than the group of RA patients with less than 10 years glucocorticoid use( $p<0.05$ ). In addition, 7 intradiscal cement leakage occurred in patients take glucocorticoid over 10 years where as no intradiscal leakage showed up in its control group( $p<0.01$ ).

**Conclusion:** KP procedure was effective for OVCF patients with or without RA, for restoring vertebral body height, reducing local kyphotic angle, relieving pain and recovering spinal function. Compared to the control group, RA patients received more improvement in compression rate and local kyphotic angle after the operation. Intradiscal leakage occurred more in patients who take glucocorticoid for over 10 years.

## Introduction

Rheumatoid arthritis(RA) is a systemic autoimmune disease with chronic, progressive and invasive arthritis and it manifests in 0.5-1% of the entire population [1]. Osteoporosis is one of the major comorbidities of RA which is caused by lots of complex pathophysiologic processes. A 2014 study reported that the prevalence of osteoporosis in RA is approximately 30%, which is at least twice as high as patients without RA [2, 3]. Nearly 50% of post-menopausal women with RA had osteoporosis [4]. Osteoporosis at epiphysis and irreversible bone destruction around the joint could occur in the early stage of RA, which following with osteoporotic changes in the whole body and even osteoporotic fracture [5].

Osteoporosis is a systematic osteopathy characterized by the reduction of bone mass per unit volume, the degradation of bone microstructure and the reduction of bone strength. The most serious complication of osteoporosis is fracture, especially in spine, in which the loss of vertebral trabecula leads to a decreased stiffness and strength of the vertebral column, even slight violence could easily lead to compression fracture. Some research shows that the longer the course of rheumatoid arthritis is, the more joint deforms with a higher incidence of osteoporotic fracture [6]. According to the epidemiological studies [1], RA patients in all age groups take higher risks of osteoporotic fracture than those without RA regardless of gender and anatomical position.

Osteoporotic vertebral compression fracture (OVCF) which occurred in 700000 cases in the US each year is the most common type of osteoporotic fracture [7]. It's reported that the Clinical vertebral fracture incidence was 4.3 per 1000 person-years, but when defining fractures using radiographic screening, the data increased to 42.4 per 1000 person-years [8]. Percutaneous vertebroplasty (VP) and kyphoplasty (KP) are the main surgical procedures, which can effectively relieve the pain in a short period of time and enable an early activity [9]; but its outcome in patients with RA is rarely reported. This study reviewed the data of 77 patients with OVCF, in which 39 patients suffered RA as well, treated by kyphoplasty in our hospital. The clinical and radiological outcomes were investigated before, after KP procedure and at the 1-year follow-up. The influence of erythrocyte sedimentation rate (ESR), c-reactive protein (CRP), volume of injected bone cement and duration of glucocorticoid use on the outcome of KP were also evaluated.

## **Materials And Methods:**

In this retrospective study, we enrolled 77 patients with 113 vertebral bodies who suffered OVCF through hospital databank. Age at procedure, sex, time taken until surgery, body mass index (BMI), bone mineral density (BMD) and bone cement injection period and amount were collected and documented. Besides, ESR and CRP was measured 2 days before the procedure. Bone mineral density was measured with dual energy X-ray absorptiometry. All enrolled patients were diagnosed with OVCF and underwent KP from January 2014 to January 2019. They were all followed up for at least 1 year after the operation. 39 patients were diagnosed with RA and osteoporosis (RA group) and the other 38 patients were osteoporotic without RA (Control group). Before KP procedure, all patients were admitted to hospital with complaints of lumbago and backache caused by no obvious inducement or slight trauma, the total duration of pain was no more than 6 month. Physical examination showed percussion pain in the corresponding segment of spinous process, and there was no evidence of spinal cord or nerve injury. All patients took thoracic and lumbar X-ray, CT scan with three-dimensional reconstruction and MRI, which confirmed that no fractures in the pedicles or posterior wall of the deformed vertebral body; MRI showed low signal of the fractured vertebral body on T1WI and high signal of STIR sequence indicated the presence of fresh fracture. All patients gained no significant improvement after conservative treatment. A representative case of OVCF was showed in Fig. 1. All patients and their families were explained the purpose, necessity, possible risks and complications of KP, and the operation was carried out after the patients signed the informed consent.

The KP procedure was performed by one surgeon under general anesthesia. C-arm fluoroscope was used to determine the fracture site and bilateral transpedicular approach was adopted. The puncture needle was penetrated into the front and middle 1/3 of the vertebral body confirmed by the lateral X-ray and the needle tip was confirmed by the anteroposterior X-ray penetrating into the center of the vertebral body. Then A balloon tamp was inserted and inflated at a pressure less than 300 mm Hg to restore the compressed vertebral body. After removing the balloon, high viscosity polymethylmethacrylate (PMMA) was injected slowly and carefully under fluoroscopy. Injectors were drawn out after the bone cement hardening. Patients started to walk 6 hours later after the procedure. Drug treatment for osteoporosis was also administered. Thoracic or lumbar X-ray and CT scan with three-dimensional reconstruction was taken 3 days after the operation and at the 1-year follow up.

To investigate radiological outcomes, PACS system tool was used to directly measure the height of the anterior edge of fractured vertebra before, after and at the end of 1 year follow-up. The local kyphotic angle was measured at the same time. Compression rate was calculated as percentile of the height of the compressed anterior vertebral body against the mean height of the anterior vertebral bodies of adjacent top and bottom vertebral bodies in lateral radiograph. For local kyphotic angle, it was examined by the angle of superior endplate of the vertebral body above the fractured vertebral body and the inferior endplate of the vertebral body below the fractured vertebral body. Figure 2 showed the measuring method for compression rate and kyphotic angle. Measurements were taken from the image at maximum zoom in order to reduce error. For cement leakage, CT scan and its three-dimensional image was used to check out the condition of cement leakage and the specific location, showed in Fig. 3. For clinical outcomes, visual analogue scale (VAS) was used to measure the degree of back pain and Oswestry disability index (ODI) was used to assess the condition of disability.

For statistical analysis, independent t-test was used to compare age, body mass index, time to surgery, bone mineral density, bone cement amount and time. Chi-square test and Fisher's exact test was used to compare gender, cement leakage and the number of glucocorticoid users. ANOVA test was used when comparing VAS, ODI, compression rate, and local kyphotic angle obtained before, after and 1-year follow-up of the procedure.

## Results:

### 1. Demographic data and clinical features

All patients included received KP procedure successfully. The average blood loss was 10 ml and the operation time was 25 min in average. No serious complications such as nerve root, spinal cord injury and massive hemorrhage occurred in all patients. No incision infection, postoperative pulmonary infection and deep vein thrombosis occurred either.

39 patients (3 males and 36 females) aged  $71.31 \pm 1.20$  (59–90) years old in RA group with 63 cases and 38 patients (5 males and 33 females) aged  $73.18 \pm 1.18$  (58–91) years old in control group with 50 cases were involved in this study. 10 patients in RA group and 4 patients in control group had two simultaneous

OVCF; three simultaneous OVCF were found in 7 patients in RA group and 4 patients in control group; 22 RA patients and 30 patients without RA suffered only one fractured vertebra, showed in Fig. 4. Besides, case number of VOPF in different site of thoracic and lumbar vertebra was showed in Fig. 5. Initial fractures in RA group included 3 case of T4 and T9 respectively; 2 cases of T5, T10 and L5 respectively; 4 cases of T6, 1 case of T8, 5 cases of T11, 10 cases of T 12 and L1 respectively; 7 cases of L2, 8 cases of L3, 6 cases of L4. Initial fractures included 1 case of T5 and T9 respectively, 2 cases of T7, T10 and L5 respectively, 3 cases of T8 and L4; 4 cases of T11; 5 cases of T12; 13 cases of L1; 8 cases of L2 and 6 cases of L6. The average BMI (kg/m<sup>2</sup>) was  $23.2 \pm 3.6$  in RA group and  $23.8 \pm 3.4$  in the control group. In addition, bone mineral density (g/cm<sup>2</sup>) was  $0.54 \pm 0.12$  and  $0.55 \pm 0.11$  in the two groups respectively. Age, gender, BMI or BMD was not significantly different between the two groups ( $p = 0.269$ ,  $p = 0.409$ ,  $p = 0.137$  and  $p = 0.361$ ). Time taken from initial injury to surgery was  $20.95 \pm 14.3$  days in RA group and it was  $16.63 \pm 19.1$  days in the control group ( $p = 0.266$ ). The average bone cement(PMMA) injection time was 10.25 minutes per vertebral body in RA group where as it was 10.18 minutes in control group( $p = 0.436$ ). The injected amount of bone cement of the two groups was  $6.20 \pm 1.54$  ml in RA group and  $6.81 \pm 2.05$  ml in the control group which shows no significant difference ( $p = 0.073$ ). All the demographic data and clinical characteristics were showed in Table 1.

## 2. Radiological, clinical outcome and cement leakage conditions between RA and its control group

After the KP procedure, we found that bone cement leakage occurred in 17 vertebral bodies in RA group (27.0%), including 7 paravertebral leakage (11.1%), 8 intradiscal leakage (12.7%) and 2 intraspinal leakage (3.17%). In the control group, leakage occurred in 10 injured vertebral bodies (20%) including 5 paravertebral leakage (10.0%), 4 intradiscal leakage (8.0%) and 1 intraspinal leakage(2.0%). No significant differences exist between the two groups no matter where the leak locations were (total  $p = 0.387$ , paravertebral  $p = 0.849$ , intradiscal  $p = 0.421$ , intraspinal  $p = 0.700$ )(Table 2). No patients showed neurological complications due to cement leakage after the operation. In RA group, ESR was  $35.82 \pm 24.2$  mm/h which is significantly higher than that in the control group( $23.16 \pm 16.9$  mm/h,  $p = 0.01$ ). However, the value of CRP demonstrated no significant difference between the two groups(RA group  $10.76 \pm 11.3$  mg/dL, control group  $8.97 \pm 12.5$  mg/dL,  $p = 0.512$ ). 34 patients in the RA group were glucocorticoid users and the average duration of taking glucocorticoid was  $14.16 \pm 11.1$  years; no patients in the control group were glucocorticoid users.

In regards to radiological outcomes, vertebral compression rate and local kyphotic angel were measured before, after and at the end of 1-year follow up. In RA group, compression rate was  $59.76 \pm 13.2\%$  before KP and it raised to  $74.97 \pm 12.0\%$  after the operation with a significant height restoration( $p < 0.01$ ). Then it decreased to  $71.32 \pm 12.2\%$  at 1-year follow up. While, in control group, compression rate was  $62.08 \pm 12.6\%$  before KP procedure which is not significantly different to RA group( $p = 0.518$ ). After the operation, the compression rate increased to  $71.15 \pm 11.8\%$ , still not different to RA group( $p = 0.311$ ), but with a significant height restoration( $p < 0.01$ ). After 1 year, compression rate decreased to  $69.10 \pm 11.9\%$  which is significantly higher than the value before KP procedure( $p < 0.01$ ). Besides the restoration of vertebral height, local kyphotic angle was measured as well. In RA group, kyphotic angle was  $7.94 \pm 5.7$ ,  $3.93 \pm 3.8$

and  $4.17 \pm 3.8$  before, after and at the end of 1-year follow up; differences among them were significant ( $p < 0.01$ ). In control group, the value was  $6.70 \pm 4.9$ ,  $3.39 \pm 3.3$  and  $3.61 \pm 3.4$  among which the differences were significant as well ( $p < 0.05$ ). But there were no significant differences between RA group and control group at the three treatment phases respectively ( $p = 0.380$ ,  $p = 0.553$ ,  $p = 0.268$ ). As to clinical outcomes, VAS score significantly decreased from  $8.11 \pm 0.87$  to  $2.02 \pm 0.68$  after KP procedure ( $p < 0.01$ ) in RA group. The VAS score was  $2.33 \pm 1.54$  after the operation for 1 year which was still statistically different with the value before KP procedure ( $p < 0.01$ ). ODI score decreased significantly from  $81.12 \pm 7.32$  before the operation to  $24.52 \pm 4.65$  after the operation ( $p < 0.01$ ). The score was  $27.31 \pm 8.11$  after 1 year ( $p < 0.01$ ). In the control group, the value of ODI score were  $84.28 \pm 6.32$ ,  $21.96 \pm 5.75$  and  $25.63 \pm 8.21$  before, after and one year after KP. The difference between preoperation and postoperation was significant ( $p < 0.01$ ). Besides, there were no significant differences of both VAS scores and ODI scores between RA group and control group at the three treatment phases respectively (VAS:  $p = 0.613$ ,  $p = 0.208$ ,  $p = 0.331$ ; ODI:  $p = 0.587$ ,  $p = 0.364$ ,  $p = 0.418$ ).

In addition, we compared the changes of compression rate, local kyphotic angle, VAS and ODI scores of the two groups between preoperation and 1 year after the operation (Table 2). The change of compression rate was  $11.56 \pm 3.8\%$  in RA group and  $7.02 \pm 3.1\%$  in the control group. The difference between the two groups was significant ( $p < 0.05$ ). The change of local kyphotic angle in RA group was  $3.77 \pm 1.9$ , which is significantly larger than that in control group ( $3.09 \pm 1.6$ ,  $p < 0.05$ ). The change of VAS score was  $5.78 \pm 0.72$  in RA group and  $5.92 \pm 0.58$  in control group ( $p = 0.517$ ). Besides, change of ODI score was  $53.81 \pm 6.52$  and  $53.81 \pm 6.52$ , respectively ( $p = 0.194$ ). Therefore, the change of compression rate and local kyphotic angle in RA patients after the KP procedure was significantly larger than the changes in the control group. The changes of VAS and ODI scores were not significantly different between the two groups.

### 3. Influence of ESR on the outcome of KP

To explore the impact of different levels of ESR on the outcome of KP in RA patients, we divided the 39 patients into three groups according to the value of ESR (Group A:  $ESR \leq 20$  mm/h, Group B:  $20$  mm/h  $< ESR \leq 50$  mm/h, Group C:  $ESR > 50$  mm/h) (Table 4). The average ESR value of the three groups were  $12.0$  mm/h,  $33.0$  mm/h and  $70.0$  mm/h, respectively ( $p < 0.01$ ). 12 female patients aged 72 years old in average with 20 fractured vertebrae were in group A. Average time taken from initial injury to surgery was 14.8 days in this group. Their average cement volume was 6.0 ml with 1 paravertebral leakage and 2 intradiscal leakage. 11 patients in this group were glucocorticoid users and the average duration of taking glucocorticoid was 13.1 years. In group B, there were 16 female and 1 male patients aged 70 years old in average with 30 cases. Average time taken from injury to surgery was 14.8 days. Their average cement volume was 6.18 ml with 4 paravertebral leakage, 4 intradiscal leakage and 1 intraspinal leakage. 14 patients in this group were glucocorticoid users and the average duration of taking glucocorticoid was 14.4 years. In group C, there were 8 female and 2 male patients aged 73 in average with 13 cases. They took 17.1 days in average to receive the operation. Their average cement volume was 6.54 ml with 2 paravertebral leakage, 2 intradiscal leakage and 1 intraspinal leakage. 9 patients in this group were

glucocorticoid users and the average duration of taking glucocorticoid was 14.83 years. In the three groups, their average CRP was 5.45 mg/dL, 13.53 mg/dL and 12.43 mg/dL, respectively ( $p = 0.143$ ). There were no significant differences among group A, B and C in aspect of age, gender, time to surgery, injected cement volume, number of glucocorticoid users, duration of taking glucocorticoid and the condition of cement leakage as well. After 1 year of the KP procedure, compression rate increased to 67.01% from 53.88% in group A, from 66.28–76.41% in group B and from 53.78–66.21% in group C; there were no significant difference among the three groups no matter before ( $p = 0.058$ ) or 1 year after the procedure ( $p = 0.071$ ). Local kyphotic angles were decreased from 8.29 to 4.45, from 7.59 to 3.90, from 8.23 to 4.30 in the three groups respectively, with no differences among them before ( $p = 0.080$ ) and 1 year after the surgery ( $p = 0.197$ ). In regards to clinical outcomes, VAS scores significantly decreased from 8.17 to 2.34 in group A, from 7.88 to 2.29 in group B and from 8.43 to 2.39 in group C; ODI scores significantly decreased from 82.01 to 27.41 in group A, from 79.38 to 26.56 in group B and from 83.01 to 28.98 in group C. There were still no differences among the three groups in clinical outcomes.

#### 4. Influence of CRP on the outcome of KP

In spite of ESR, 39 RA patients were divided into three groups according to the value of CRP as well (Group D:  $CRP \leq 5$  mg/dL, Group E:  $5$  mg/dL  $< CRP \leq 10$  mg/dL, Group F:  $CRP > 10$  mg/dL) (Table 5). The average CRP value of the three groups were 1.65 mg/dL, 7.65 mg/dL and 22.34 mg/dL respectively ( $p < 0.01$ ). 1 male and 13 female patients aged 74 in average with 26 cases were in group D. Their average cement volume was 5.94 ml with 4 paravertebral leakage and 5 Intradiscal leakage. 12 patients in group D were glucocorticoid users and the average duration of taking glucocorticoid was 15.1 years. In group E, 11 female patients aged 70 in average with 16 injured vertebrae. Their average cement volume was 6.38 ml with 2 Intradiscal leakage and 1 intraspinal leakage. 9 patients in this group were glucocorticoid users and the average duration of taking glucocorticoid was 16.0 years. In group F, there were 12 female and 2 male patients aged 70 in average with 21 fractured vertebrae. Their average cement volume was 6.38 ml as well with 3 paravertebral leakage, 1 intradiscal leakage and 1 intraspinal leakage. 13 patients in this group were glucocorticoid users and the average duration of taking glucocorticoid was 12.0 years. In average, the time taken from initial injury to surgery was 27.1 days in group D, 15.4 days in group E and 19.4 days in group F, and their average value of ESR were 31 mm/h, 42 mm/h and 36 mm/h, respectively ( $p = 0.514$ ). There were no significant differences among group D, E and F in aspect of age, gender, time to surgery, injected cement volume, number of glucocorticoid users, duration of taking glucocorticoid and the condition of cement leakage. After 1 year of the KP procedure, compression rate increased to 76.21% from 63.28% in group D, from 52.08–64.31% in group E and from 60.78–70.21% in group F; there were no significant differences among the three groups no matter before ( $p = 0.150$ ) or 1 year after the procedure ( $p = 0.081$ ). Local kyphotic angles were decreased from 7.95 to 3.855, from 8.62 to 5.26, from 7.41 to 3.74 in the three groups respectively, with no differences among them before ( $p = 0.092$ ) and 1 year after the surgery ( $p = 0.074$ ). In regards to clinical outcomes, VAS scores decreased from 8.05 to 2.27 in group D, from 8.23 to 2.41 in group E and from 7.98 to 2.27 in group F; ODI scores decreased from 80.16 to 27.02, from 83.01 to 28.06 and from 79.06 to 26.38 in the three groups, and there were still no differences among the three groups in clinical outcomes.

## 5. Influence of injected cement volume on the outcome of KP

We studied the influence of injected cement volume on the outcome of KP in patients with RA. 63 injured vertebrae were divided into 2 groups according to the cement volume (Group J: cement volume  $\leq$  6 ml, Group K: cement volume  $>$  6 ml)(Table 6). The average cement volume was 5.19 ml in group J and 7.54 ml in group K ( $p < 0.01$ ). Patients included in group J owned at least 1 fractured vertebra in which the injected cement volume was less than 6 ml, thus 23 female patients and 2 male patients aged 70.8 years old in average were in group J. The average time taken from initial injury to surgery was 24.36 days in this group. There were 4 paravertebral leakage, 3 Intradiscal leakage and 2 intraspinal leakage after the procedure. The average value of ESR and CRP in group J was 32.4 mm/h and 10.1 mg/dL. 21 patients in this group were glucocorticoid users and the average duration of taking glucocorticoid was 13.4 years. In group K, there were 21 female and 2 male patients aged 70.4 years old in average with 37 fractured vertebrae. Patients in this group owned at least 1 fractured vertebra in which the injected cement volume was more than 6 ml. Average time taken from initial injury to surgery was 20.27 days. There were 3 paravertebral leakage and 4 Intradiscal leakage after the procedure. The average value of ESR and CRP in group K was 35.2 mm/h and 11.5 mg/dL, respectively. 19 patients in this group were glucocorticoid users and the average duration of taking glucocorticoid was 13.8 years. There were no significant differences between group J and K in aspect of age, gender, time to surgery, ESR, CRP, number of glucocorticoid users, duration of taking glucocorticoid and the condition of cement leakage. After 1 year of the KP procedure, compression rate increased to 70.34% from 61.52% in group J and from 57.53–72.58% in group L; there were no significant difference between the two groups no matter before ( $p = 0.389$ ) or 1 year after the procedure ( $p = 0.598$ ). Local kyphotic angles were decreased from 7.79 to 4.59, from 8.13 to 3.62 in the two groups respectively, with no differences between them before ( $p = 0.771$ ) and 1 year after the surgery (0.482). In regards to clinical outcomes, VAS scores decreased from 8.06 to 2.30 in group J and from 8.16 to 2.36 in group K. Besides, ODI scores decreased from 81.14 to 27.56 in group J and from 81.10 to 27.04 in group K. There were still no difference between the two groups in clinical outcomes.

## 6. Influence of glucocorticoid taking duration on the outcome of KP

At last, we explore the impact of glucocorticoid taking duration on the outcome of KP in RA patients. 34 glucocorticoid users were divided into 2 groups according to the duration of taking glucocorticoid (Group L: Glucocorticoid use  $\leq$  10 years, Group M: Glucocorticoid use  $>$  10 years). The average time of taking glucocorticoid was 5.81 years in group L and 23.55 years in group M ( $p < 0.01$ ). 15 female patients and 3 male patients aged 70.1 years old in average with 33 fractured vertebrae were in group L. Average time taken from initial injury to surgery was 24.24 days in this group. The average cement volume was 6.03 ml with 4 paravertebral leakage after KP procedure in group L. The average value of ESR and CRP in group J was 33.9 mm/h and 12.0 mg/dL respectively. In group M, there were 16 female patients aged 71.9 years old in average with 25 fractured vertebrae. Average time taken from initial injury to surgery was 20.9 days in this group. The average cement volume was 6.38 ml with 2 paravertebral leakage, 7 intradiscal leakage and 2 intraspinal leakage after the procedure. The average value of ESR and CRP in group M was 33.2 mm/h and 9.52 mg/dL. There were no significant differences between group L and M in aspect of

age, time to surgery, ESR, CRP and injected cement volume. But the number of cement leakage in Group L was significantly less than the other group ( $p < 0.05$ ), especially the intradiscal leakage ( $p < 0.01$ ). After 1 year of the KP procedure, compression rate increased to 69.97% from 58.57% in group L and from 61.05–72.80% in group L; there were no significant differences between the two groups no matter before ( $p = 0.585$ ) or 1 year after the procedure ( $p = 0.502$ ). Local kyphotic angles were decreased from 8.01 to 3.98, from 7.86 to 4.38 in the two groups respectively, with no differences between them before ( $p = 0.944$ ) and 1 year after the surgery (0.774). In regards to clinical outcomes, VAS scores decreased from 8.13 to 2.31 in group L and from 8.09 to 2.35 in group M. Besides, ODI scores decreased from 81.90 to 26.78 in group L and from 80.38 to 27.81 in group M. There were still no difference between the two groups in clinical outcomes.

## Discussion

It is well known that rheumatoid arthritis progresses with destruction of bone microstructure and the loss of bone mass, thus increasing the incidence of osteoporotic fracture. Lee et al. reported that the incidence of osteoporosis in patients with RA was 22.1%, which is approximately twice that in healthy people (11.4%) [10]. In the study by Ghazi et al, the incidence of OVCF was 21.7% in female RA patients which was significantly higher than control group (4.2%)[11]. Tong et al. found that the incidence of OVCF in RA patients was 19.2%, which was almost 5 times the rate in the healthy group [5]. In our study, the most common fractured vertebra in RA patients was T12 (15.9%) and L1 (15.9%), while in control group, the most common fractured vertebra was L1 (26.0%). Besides, OVCF at more than one site was more common in RA. 10 patients in the RA group and 4 patients in the control group had two simultaneous OVCF; three simultaneous OVCF were found in 7 patients in RA group and 4 patients in control group.

Traditional conservative management of OVCF includes oral medication and bracing on the bed strictly. Long term bed rest would further aggravate osteoporosis and lead to bedsore, lung infection, depression and other complications with an increased mortality in the elderly. Besides, the height of vertebral body would lose, chronic back pain and local kyphosis arise due to a worse compliance [12]. The effects of KP, VP and conservative treatment for OVCF was reviewed by Papanastassiou et al, KP and VP showed an improved pain reducing effect over conservative management; KP demonstrated enhanced results for quality of life improvement over VP [13]. Voggenreiter [14] showed that kyphoplasty could restore vertebral height through balloon inflation and dynamic fracture mobility, which is also supported by lots of clinical studies [15, 16]. Besides, Lovi et al. reported that the vertebral height restoration effect of KP was higher than VP in 2-year follow-ups [17]. Therefore, surgical treatment especially KP is recommended for patients with OVCF. However, few articles reported the effect of KP in RA patients with OVCF. Considering a high risk of death and other complications of OVCF, the safety and efficacy of KP in RA patients need more analysis and exploration.

In this study, no matter in OVCF patients with or without RA, the vertebral compression rate significantly increased after the KP procedure, while the local kyphotic angle significantly decreased. At the time of 1 year follow-up, radiological changes were still statistically significant when compared to the data before

KP. VAS and ODI scores were also significantly decreased after the procedure. In addition, we compared the change of compression rate, local kyphotic angle, VAS and ODI scores before and 1 year after KP procedure. The results showed that the change of compression rate was  $11.56 \pm 3.8\%$  in RA group and  $7.02 \pm 3.1\%$  in the control group; the difference between them was significant. The change of local kyphotic angle in RA group was  $3.77 \pm 1.9$ , which is also significantly larger than that in control group. Where as, the change of VAS and ODI scores were not different between the two groups. The higher vertebral compression rate after balloon KP indirectly indicated weaker bone quality in patients with RA. Therefore, balloon KP in OVCF patients with RA could correct deformations more effectively when compared to non-RA patients. However, for the OVCF patients with posterior wall rupture, spinal canal occupation and severe kyphotic deformity, there is a risk of bone cement leakage in the spinal canal and the bone block penetrating into the spinal canal leading to secondary nerve injury. This type of fracture is considered as the relative contraindication of KP.

As to the reason of the prevalence of osteoporosis increases in RA patients, on the one hand, it may be related to the inflammatory state of RA, abnormal bone metabolism, bone destruction and joint erosion caused by high activity of disease [18, 19]; on the other hand, it may be related to the application of glucocorticoid, methotrexate and other drugs in the treatment of RA patients. Glucocorticoid therapy is widely used in RA for its function in decreasing disease activity and inflammation-related bone erosion. But Long-term glucocorticoid treatment leads to decreased osteogenesis and osteoporosis by inhibiting the activity of osteoblasts, promoting osteoclasts mediated bone resorption and bone matrix decomposition [20]. Therefore, the effect of glucocorticoid therapy on OVCF in patients with RA needs more elaboration. In our study, there were no significant radiological and clinical differences among the three groups with different levels of ESR no matter before or 1 year after the procedure. But the percentage of cement leakage is higher along with the increase of ESR. Besides, differences among the three groups with different levels of CRP were also insignificant before and 1 year after the operation. Van Staa et al. reported that strong correlations between the cumulative glucocorticoid dose and BMD decrease, and between the daily glucocorticoid dose and the risk of fracture [21]. Where as in our study, there were no significant radiological and clinical differences between the two groups with different duration of glucocorticoid use no matter before or 1 year after the procedure. But the percentage of cement leakage is 44.0% in group of over 10 years glucocorticoid use,, which is much higher than group L.

The leakage of bone cement is the most common complication of KP. The leakage location includes nerve roots canal, intraspinal epidural space, paravertebral soft tissue, intervertebral disc, paravertebral venous plexus and puncture needle channels. The main reasons are related to the viscosity and injection volume of bone cement, cause of the fracture, extent of compression and other factors [22–24]. In our study, the percentage of cement leakage between the two groups of different cement volume was not statistically different, and the only 2 intraspinal leakage occurred in the group of less cement volume. Besides, the value of ESR and CRP did not impact the leak conditions as well. But the number of cement leakage in Group L in which all patients take glucocorticoid less than 10 years was significantly less than the other group ( $p < 0.05$ ). In specific, no statistical differences exist in paravertebral and intraspinal leakage. Where as, intradiscal leakage occurred more in patients take glucocorticoid for over 10 years. In addition, there

were no significant radiological and clinical differences between the two groups with different injected cement volume no matter before or 1 year after the procedure. However, the change of local kyphotic angle is larger in group K in which the injected cement volume were all more than 6 ml.

During kyphoplasty, the incidence of bone cement leakage is from 11.3 to 33% [25, 26]. Lin et al. stated that bone cement leakage increased three-fold when the end plate was fractured, and intradiscal cement leakage increased the risk of adjacent fracture by four-fold [27]. Generally, leakage in paravertebral soft tissue and intervertebral disc has no obvious symptoms. Leakage in nerve root canals may cause radicular pain and the leakage into spinal canal may cause spinal cord or cauda equina nerve compression. Pulmonary embolism, hypoxemia, shock and pulmonary hypertension may happen if bone cement is too thin to leak into paravertebral vein and then return to pulmonary artery [28]. Therefore, strict indications and proficient manipulation is necessary to prevent the complications related to the leakage of bone cement. Once leakage is found, close observation is necessary for asymptomatic patients; those with mild symptoms could be treated with nonsteroidal anti-inflammatory drugs. While, the leak bone cement should be removed by surgery or receive corresponding rescue in some serious condition.

This study revealed some characteristics of the outcome of KP in RA patients who suffered OVCF. But there were several limitations as well. First of all, it was a retrospective study and the number of included patients and cases was not large. Secondly, there was no data about sagittal imbalance of the spine. Thirdly, there was no quantitatively comparison on the dosage of glucocorticoid use in RA patients. Therefore, additional prospective studies with a quantitative design are requisite for a better exploration on VOFC in RA patients.

## Conclusions

KP procedure was effective for OVCF patients with or without RA, for reducing kyphotic angle, relieving pain and restoring vertebral body height and spinal function. Compared to the control group, RA patients received more improvement in compression rate and local kyphotic angle after the operation. Whereas, the change of VAS and ODI scores were not different between patients with or without RA. At last, ESR, CRP, injected cement volume and duration of taking glucocorticoid didn't significantly affect the radiological and clinical outcomes, but intradiscal leakage occurred more in patients take glucocorticoid for over 10 years.

## Declarations

**Ethics approval and consent to participate** Seen in the attach files

**Consent for publication** Seen in the attach files

**Availability of data and materials**The datasets used during the current study are available from the corresponding author on reasonable request and all data analysed during this study are included in this published article.

### **Conflict of interest**

The authors declare that they have no competing interests.

### **Funding**

This study was supported by National Natural Science Foundation of China (Grant No. 81972118), Shanghai Municipal Population and Family Planning Commission (Grant No. 201840361), Shanghai Changning District Science and Technology Committee (Grant No. CNKW2017Z05) , Shanghai Changning District Science and Technology Committee (Grant No. CNKW2018Y13) and “Star of Hope” educational program (Grant No. 2020100100052).

### **Authors' contributions**

Ji Guo, Yongwei Jia and Licheng Wei operated all the KP procedure; Ji Guo was a major contributor in writing the manuscript. All other authors did the post-operative work and collecting work. All authors read and approved the final manuscript.

**Acknowledgements**Not applicable

## **Abbreviations**

KP kyphoplasty

OVCF osteoporotic vertebral compression fracture

RA rheumatoid arthritis

ESR erythrocyte sedimentation rate

CRP c-reactive protein

VAS visual analogue scale

ODI Oswestry disability index

VP vertebroplasty

Preop preoperation

Postop postoperation

FU follow up

## Tables

Table 1  
Demographic data and clinical features

Variable	RA Group	Control group	P-value
Patients	39(63 cases)	38(50cases)	
Age(year)	71.31 ± 7.49	73.18 ± 7.27	0.269
Gender(Male:Female)	3:36	5:33	0.409
BMI(kg/m <sup>2</sup> )	23.2 ± 3.6	23.8 ± 3.4	0.137
BMD(g/cm <sup>2</sup> )	0.54 ± 0.12	0.55 ± 0.11	0.361
Time to surgery(days)	20.95 ± 14.3	16.63 ± 19.1	0.266
Cement time(min)	10.25 ± 3.5	10.18 ± 4.1	0.436
ESR(mm/h)	35.82 ± 24.2	23.16 ± 16.9	0.010
CRP(mg/dL)	10.76 ± 11.3	8.97 ± 12.5	0.512
Glucocorticoid users	34	0	< 0.01
Duration of taking glucocorticoid(year)	14.16 ± 11.1	0	< 0.01
Cement volume(mL)	6.20 ± 1.54	6.81 ± 2.05	0.073
Values are given as mean ± SD. RA indicates rheumatoid arthritis, BMI indicates body mass index, BMD indicates bone mineral density, ESR indicates erythrocyte sedimentation rate, CRP indicates c-reactive protein.			

Table 2  
Conditions of cement leakage and the changes of radiological and clinical outcomes of KP

Variable	RA Group	Control group	P-value
Cement leakage(case)			
Total cement leakage	17(27.0%)	10(20%)	0.387
Paravertebral cement leakage	7(11.1%)	5(10.0%)	0.849
Intradiscal cement leakage	8(12.7%)	4(8.0%)	0.421
Intraspinal cement leakage	2(3.17%)	1(2.0%)	0.700
Radiological outcomes			
Changes of compression rate(%)	11.56 ± 3.8%	7.02 ± 3.1%	< 0.05
Changes of local kyphotic angle(°)	3.77 ± 1.9	3.09 ± 1.6	< 0.05
Clinical outcomes			
Changes of VAS	5.78 ± 0.72	5.92 ± 0.58	0.517
Changes of ODI	53.81 ± 6.52	53.81 ± 6.52	0.194
<p>Values are given as mean ± SD. VAS indicates visual analog scale, ODI indicates Oswestry disability index. Changes of compression rate showed the difference of compression rate between preoperation and 1 year follow up; Changes of local kyphotic angle showed the difference of local kyphotic angle between preoperation and 1 year follow up; Changes of VAS showed the difference of visual analog scale between preoperation and 1 year follow up; Changes of ODI showed the difference of Oswestry disability index between preoperation and 1 year follow up.</p>			

Table 3

Control Group	Group	Preop	Postop	1 year FU	P value(Preop-Postop)	P value(Preop-1 year FU)
Compression rate(%)	RA	59.76 ± 13.2%	74.97 ± 12.0%	71.32 ± 12.2%	< 0.01	< 0.01
	Control	62.08 ± 12.6%	71.15 ± 11.8%	69.10 ± 11.9%	< 0.01	< 0.01
	P value	0.518	0.311	0.706		
Local kyphotic angle(°)	RA	7.94 ± 5.7	3.93 ± 3.8	4.17 ± 3.8	< 0.01	< 0.01
	Control	6.70 ± 4.9	3.39 ± 3.3	3.61 ± 3.4	< 0.05	< 0.05
	P value	0.380	0.553	0.268		
VAS	RA	8.11 ± 0.87	2.02 ± 0.68	2.33 ± 1.54	< 0.01	< 0.01
	Control	8.36 ± 0.69	2.21 ± 0.54	2.44 ± 1.67	< 0.01	< 0.01
	P value	0.613	0.208	0.331		
ODI	RA	81.12 ± 7.32	24.52 ± 4.65	27.31 ± 8.11	< 0.01	< 0.01
	Control	84.28 ± 6.32	21.96 ± 5.75	25.63 ± 8.21	< 0.01	< 0.01
	P value	0.587	0.364	0.418		
Values are given as mean ± SD. FU indicates follow up, Preop indicates preoperation, Postop indicates postoperation, VAS indicates visual analog scale, ODI indicates Oswestry disability index.						

Table 4

Variable		Group A: ESR ≤ 20 mm/h	Group B: 20 mm/h < ESR ≤ 50 mm/h	Group C: ESR > 50 mm/h	P- value
Patients		12(20cases)	17(30cases)	10(13cases)	
Age(year)		72	70	73	0.356
Gender(Male:Female)		0:12	1:16	2:8	0.201
Time to surgery		14.8	27.6	17.1	0.584
ESR(mm/h)		12	33	70	< 0.01
CRP(mg/dL)		5.45	13.53	12.43	0.143
Glucocorticoid users		11	14	9	0.726
Duration of taking glucocorticoid(year)		13.1	14.4	14.83	0.939
Cement volume(mL)		6.0	6.18	6.54	0.625
Cement leakage(case)		3(15.0%)	9(30.0%)	5(38.8%)	0.310
Paravertebral leakage		1	4	2	0.564
Intradiscal leakage		2	4	2	0.893
Intraspinal leakage		0	1	1	0.467
Radiological outcomes					
Compression rate(%)	Preop	53.88%	66.28%	53.78%	0.058
	1 year FU	67.01%	76.41%	66.21%	0.071
Local kyphotic angel(°)	Preop	8.29	7.59	8.23	0.080
	1 year FU	4.45	3.90	4.30	0.197
Clinical outcomes					
VAS	Preop	8.17	7.88	8.43	0.345
	1 year FU	2.34	2.29	2.39	0.716
ODI	Preop	82.01	79.38	83.01	0.561
	1 year FU	27.41	26.56	28.98	0.592

Values are given as mean ± SD. ESR indicates erythrocyte sedimentation rate, CRP indicates c-reactive protein, Preop indicates preoperation, FU indicates follow up, VAS indicates visual analog scale, ODI indicates Oswestry disability index.

Table 5

Variable		Group D:	Group E:	Group F:	P value
		CRP ≤ 5 mg/dL	5 mg/dL < CRP ≤ 10 mg/dL	CRP > 10 mg/dL	
Patients		14(26cases)	11(16cases)	14(21cases)	
Age(year)		74	70	70	0.398
Gender(Male:Female)		1:13	0:11	2:12	0.411
Time to surgery		27.1	15.4	19.4	0.107
ESR(mm/h)		31	42	36	0.514
CRP(mg/dL)		1.65	7.65	22.34	< 0.01
Glucocorticoid users		12	9	13	0.700
Duration of taking glucocorticoid (year)		15.1	16.0	12.0	0.107
Cement volume(mL)		5.94	6.38	6.38	0.551
Cement leakage(case)		9(34.6%)	3(17.6%)	5(23.8%)	0.489
Paravertebral leakage		4	0	3	0.271
Intradiscal leakage		5	2	1	0.334
Intraspinal leakage		0	1	1	0.468
Radiological outcomes					
Compression rate(%)	Preop	63.28%	52.08%	60.78%	0.150
	1 year FU	76.21%	64.31%	70.21%	0.081
Local kyphotic angel(°)	Preop	7.95	8.62	7.41	0.092
	1 year FU	3.85	5.26	3.74	0.074
Clinical outcomes					
VAS	Preop	8.05	8.23	7.98	0.563
	1 year FU	2.27	2.41	2.27	0.585
ODI	Preop	80.16	83.01	79.06	0.412
	1 year FU	27.02	28.06	26.38	0.493

Values are given as mean ± SD. ESR indicates erythrocyte sedimentation rate, CRP indicates c-reactive protein, Preop indicates preoperation, FU indicates follow up, VAS indicates visual analog scale, ODI indicates Oswestry disability index.

Table 6

Variable	Group J: Cement Volume $\leq$ 6 ml		Group K: Cement Volume > 6 ml	P value
	Patients	25		
Cases	36		27	
Age(year)	70.8		70.4	0.857
Gender(Male:Female)	2: 23		2:21	0.999
Time to surgery	24.36		20.27	0.300
ESR(mm/h)	32.4		35.2	0.627
CRP(mg/dL)	10.1		11.5	0.664
Glucocorticoid users	21		19	0.326
Duration of taking glucocorticoid(year)	13.4		13.8	0.872
Cement volume(mL)	5.19		7.54	< 0.01
Cement leakage(case)	10(27.8%)		7(25.9%)	0.870
Paravertebral leakage	4		3	0.999
Intradiscal leakage	3		4	0.449
Intraspinal leakage	2		0	0.507
Radiological outcomes				
Compression rate(%)	Preop	61.52%	57.53%	0.389
	1 year FU	70.34%	72.58%	0.598
Local kyphotic angel(°)	Preop	7.79	8.13	0.771
	1 year FU	4.59	3.62	0.482
Clinical outcomes				
VAS	Preop	8.06	8.16	0.898
	1 year FU	2.30	2.36	0.783
ODI	Preop	81.14	81.10	0.903
	1 year FU	27.56	27.04	0.756
Values are given as mean $\pm$ SD. ESR indicates erythrocyte sedimentation rate, CRP indicates c-reactive protein, Preop indicates preoperation, FU indicates follow up, VAS indicates visual analog scale, ODI indicates Oswestry disability index.				

Table 7

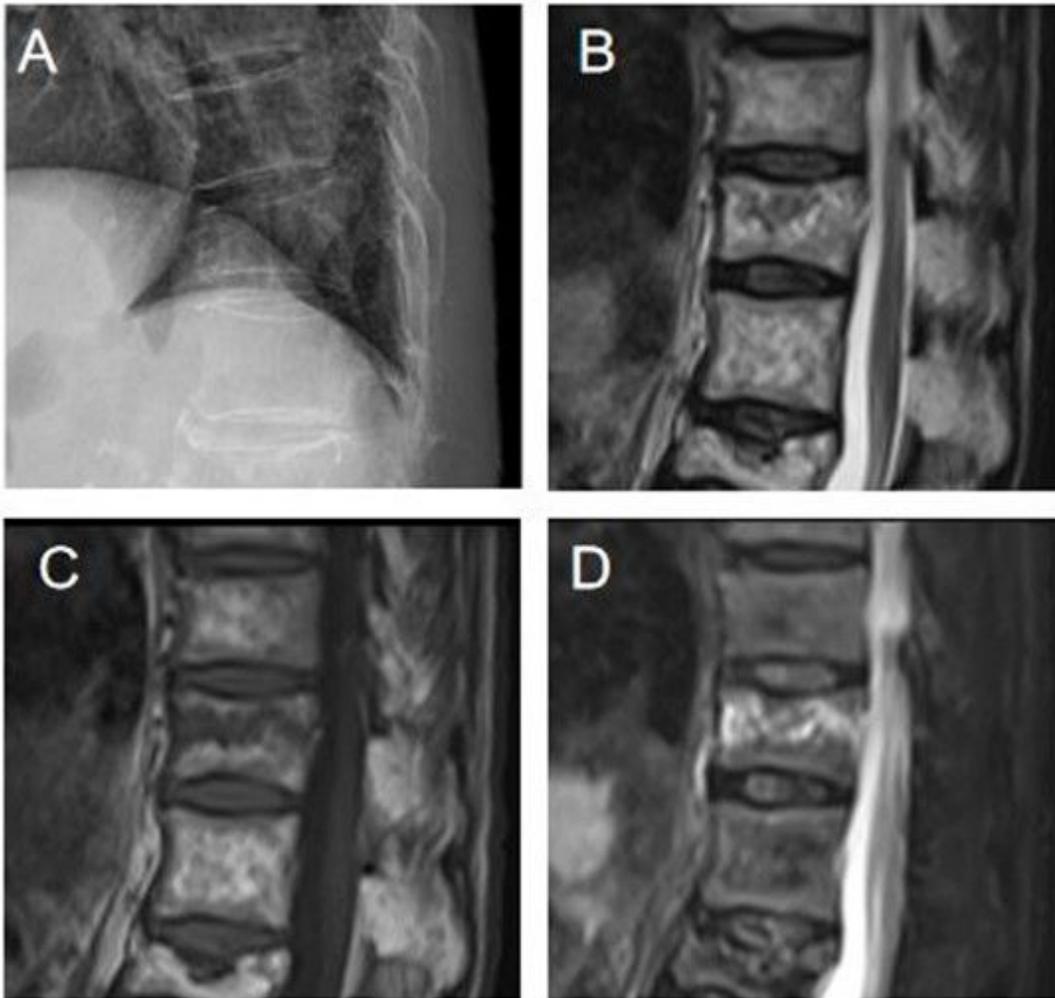
Variable	Group L:		Group M:		P-value
	Glucocorticoid use $\leq$ 10 years		Glucocorticoid use > 10 years		
Patients/Glucocorticoid users	18(33cases)		16(25cases)		
Age(year)	70.1		71.9		0.446
Gender(Male:Female)	3:15		0:16		0.230
Time to surgery	24.24		20.9		0.382
ESR(mm/h)	33.9		33.2		0.906
CRP(mg/dL)	12.0		9.52		0.161
Duration of taking glucocorticoid(year)	5.81		23.55		< 0.01
Cement volume(mL)	6.03		6.38		0.369
Cement leakage(case)	4(12.1%)		11(44.0%)		< 0.05
Paravertebral leakage	4		2		0.690
Intradiscal leakage	0		7		< 0.01
Intraspinal leakage	0		2		0.182
Radiological outcomes					
Compression rate(%)	Preop	58.57%	61.05%		0.585
	1 year FU	69.97%	72.80%		0.502
Local kyphotic angel(°)	Preop	8.01	7.86		0.944
	1 year FU	3.98	4.38		0.774
Clinical outcomes					
VAS	Preop	8.13	8.09		0.952
	1 year FU	2.31	2.35		0.864
ODI	Preop	81.90	80.38		0.749
	1 year FU	26.78	27.81		0.706

Values are given as mean  $\pm$  SD. ESR indicates erythrocyte sedimentation rate, CRP indicates c-reactive protein, Preop indicates preoperation, FU indicates follow up, VAS indicates visual analog scale, ODI indicates Oswestry disability index.

## References

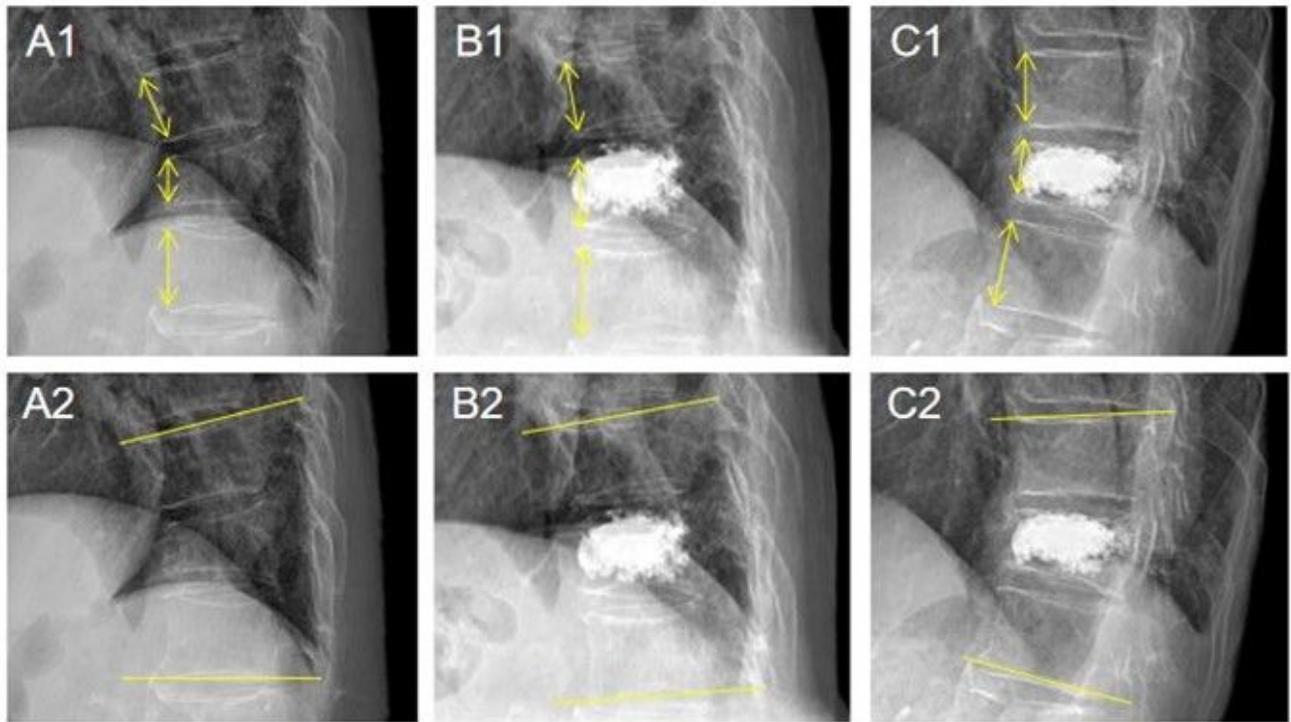
References are not available in this version.

## Figures



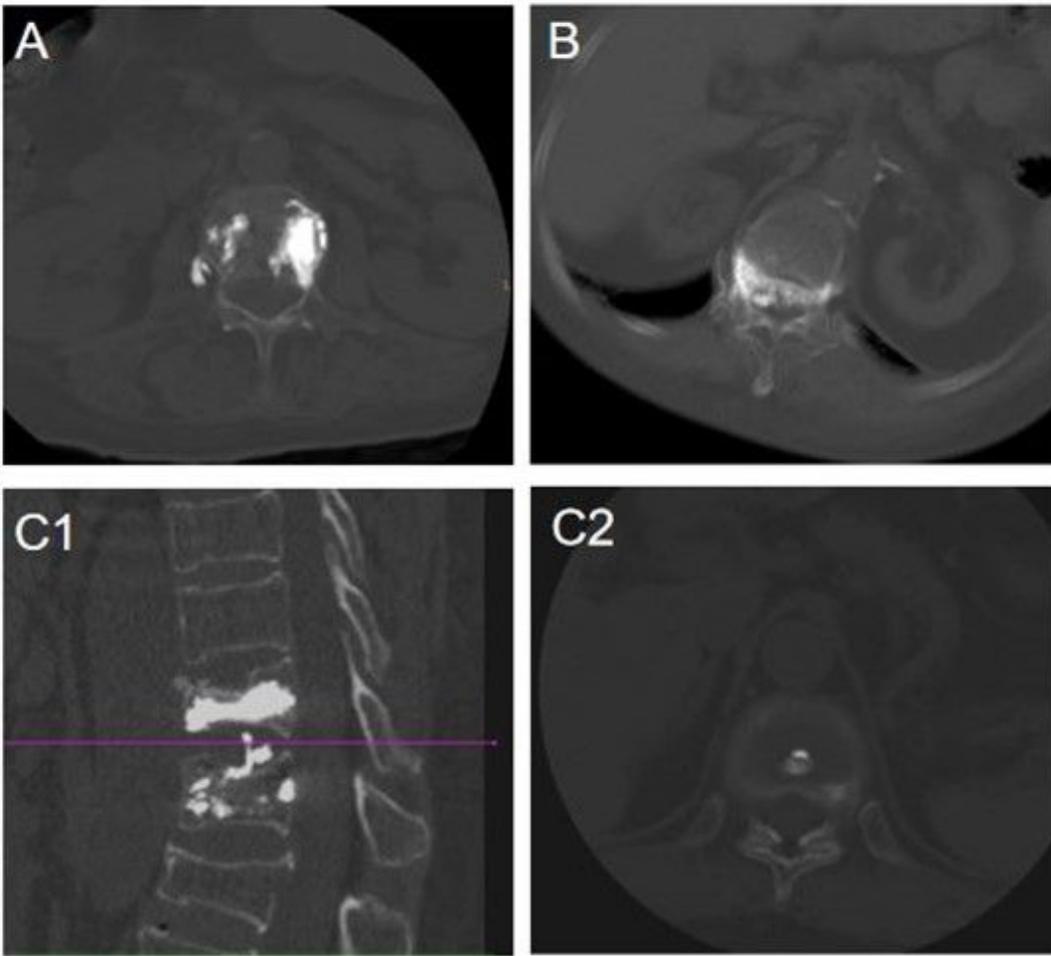
**Figure 1**

A 84-year-old female patient visited for the lumbago after she slipped and there was a T11 vertebral body fracture based on the lateral plain radiograph(A). A recent fracture in T2WI(B), T1WI(C) and fat suppression image(D) was confirmed based on the MRI.



**Figure 2**

The preoperative compression rate was calculated as the percentile of the height of the compressed anterior vertebral body against the mean height of adjacent top and bottom vertebral bodies in the lateral radiograph(A1). The preoperative local kyphotic angle was examined by the angle of superior endplate of the vertebral body above the fractured vertebral body and the inferior endplate of the vertebral body below the fractured vertebral body(A2). The postoperative compression rate and kyphotic angle were determined in the same manner as that prior to surgery(B1, B2). The 1 year follow up compression rate and kyphotic angle were determined in the same method(C1, C2).



**Figure 3**

Representative images of cement leakage on computed tomographic scan. Paravertebral cement leakage in transverse view(A). Intraspinal cement leakage in transverse view(B). Intradiscal cement leakage in sagittal and transverse view(C1,C2).

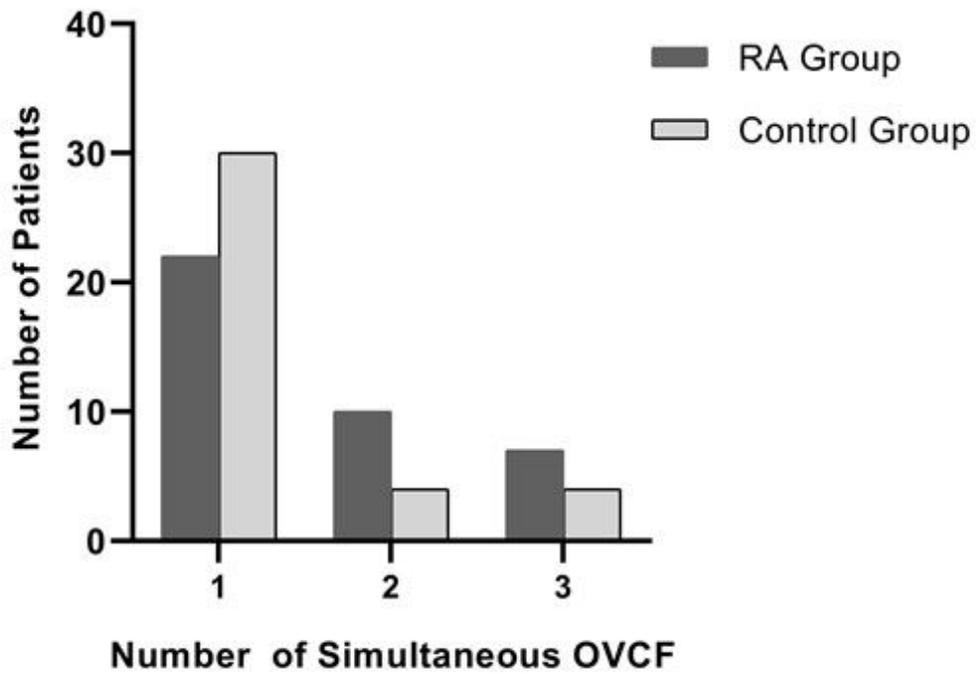


Figure 4

Case number of simultaneous OVCF in RA group and its control group.

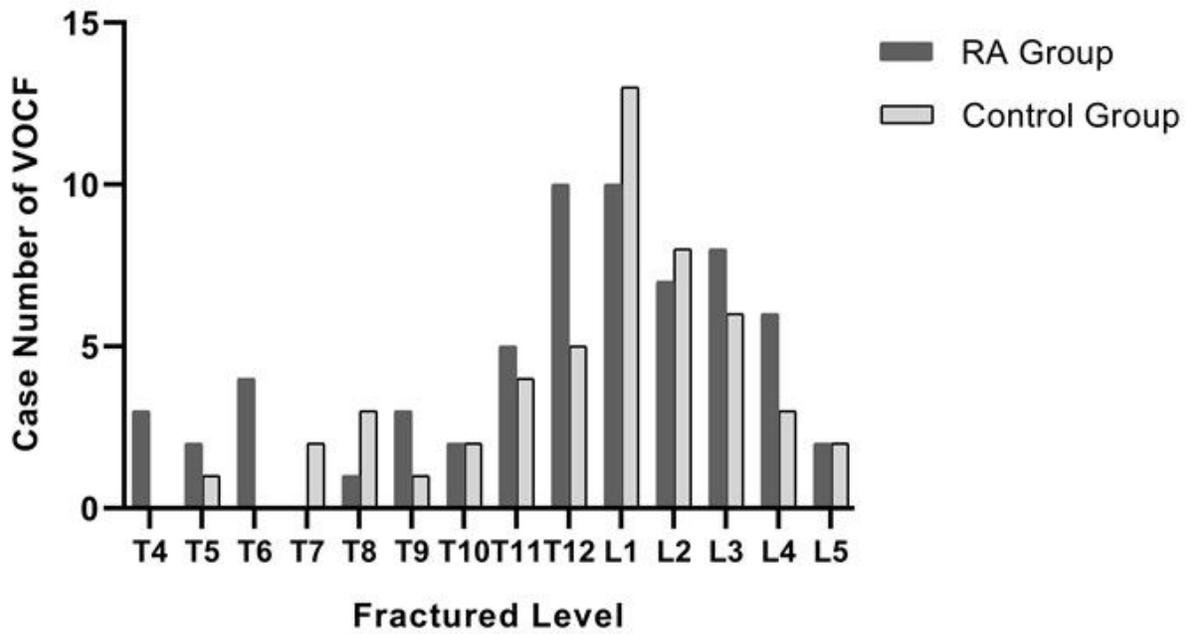


Figure 5

Case number of VOPF in different site of thoracic and lumbar vertebra (T4-L5) in RA group and its control group. T indicates thoracic spine, L lumbar spine.

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [ZhengHuang.pdf](#)
- [ZhengHuang.pdf](#)
- [YongweiJia.pdf](#)
- [YongweiJia.pdf](#)
- [WeifengZhai.pdf](#)
- [WeifengZhai.pdf](#)
- [LichengWei.pdf](#)
- [LichengWei.pdf](#)
- [HaoYan.pdf](#)
- [HaoYan.pdf](#)
- [JiGuo.pdf](#)
- [JiGuo.pdf](#)
- [JianpoZhang.pdf](#)
- [JianpoZhang.pdf](#)
- [LangJin.pdf](#)
- [LangJin.pdf](#)