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*Original Article*

# Risk factors for lumbar fascial edema in patients with osteoporotic vertebral compression fractures and its effect on residual pain after percutaneous vertebroplasty

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**Abstract:** Objective: To identify risk factors for lumbar fascial edema (LFE) in patients with osteoporotic vertebral compression fractures (OVCF) and evaluate its impact on residual pain after percutaneous vertebroplasty (PVP). Methods: A retrospective analysis was conducted on 360 OVCF patients who underwent PVP from January 2020 to March 2025. Based on MRI findings, patients were categorized into the LFE group (n=131) and non-LFE group (NLFE; n=229). Univariate and multivariate logistic regression analyses were used to identify independent risk factors, and receiver operating characteristic (ROC) curve analysis was used to assess their diagnostic value. Clinical parameters, including the presence or absence of edema, numerical rating scale (NRS) pain score, modified Oswestry disability index (ODI), C-reactive protein (CRP) and interleukin-6 (IL-6) levels, and postoperative residual pain were compared between patients in different age groups. Results: Multivariate analysis identified age, history of trauma, presence of lumbar instability, and old vertebral compression fractures as independent risk factors for LFE ($P<0.05$). ROC curve analysis confirmed their significant diagnostic value. Compared with the NLFE group, the LFE group had significantly higher NRS and ODI scores, residual pain incidence, CRP, and IL-6 levels ($P<0.05$). Patients aged ≥70 years had significantly higher values for these parameters than those <70 years ($P<0.05$). Conclusion: Advanced age, trauma history, lumbar instability, and old vertebral compression fractures are significant risk factors for LFE in OVCF patients. The presence of LFE is associated with a higher incidence of postoperative residual pain.

**Keywords:** Osteoporotic vertebral compression fracture, lumbar fascial edema, vertebroplasty, residual pain, inflammatory factors

## Introduction

Osteoporosis is a systemic orthopedic disorder prevalent among middle-aged and elderly individuals, characterized by reduced bone mass, impaired bone microstructure, increased bone fragility, and decreased bone strength, predisposing patients to osteoporotic fractures [1]. Among these, osteoporotic vertebral compression fracture (OVCF) is the most common type, primarily presenting with low back pain and spinal kyphosis. These symptoms not only severely restrict patients' mobility but also exert a significant adverse impact on patients' quality of life and family functioning [2]. With the accelerating aging of China's population, the annual incidence of new OVCF cases nationwide is projected to reach 3.01 million by 2050 [3], underscoring its growing public health burden.

Lumbar fascial edema (LFE) is a common comorbidity in OVCF patients. Magnetic resonance imaging (MRI) features typically include hypointensity on T1-weighted imaging (T1WI), hyperintensity on T2-weighted imaging (T2WI), and hyperintensity on T2WI fat-saturated sequences in the lumbar dorsal myofascia and overlying subcutaneous tissues [4]. The pathogenesis of LFE is closely associated with lumbar vertebral fractures. Chronic lumbar strain, repeated muscle traction, and cold-humid environmental exposure predispose the lumbar dorsal myofascia and muscle tissues to edema, exudation, and fibrous degeneration; these

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pathological changes further induce local fascial adhesion, hypertrophy, scarring, and contracture, resulting in loss of fascial elasticity during the edematous phase [5, 6]. Consequently, compression and stimulation of surrounding muscles and nerve tissues occur, producing clinical symptoms predominantly characterized by local pain. Such MRI findings are common in clinical practice, and the recurrent nature of LFE symptoms can severely impair patients' work capacity and quality of life.

Clinically, the etiology of LFE remains incompletely understood, though it is generally considered to be associated with traumatic sequelae, a history of prior surgery or interventional therapy, and infectious infiltration [7]. Additionally, localized or generalized soft tissue edema may result from cardiac, renal, or hepatic disorders, malignant lymphadenopathy, venous thrombosis, allergic reactions, burns, or the administration of certain medications [8]. Notably, most patients with OVCF tend to experience residual pain of varying severity following vertebroplasty, which adversely affects their postoperative recovery [9]. However, studies investigating the risk factors for LFE in OVCF patients and the potential impact of this complication on residual pain following vertebroplasty remain limited.

The present study was designed with three primary objectives: first, to identify independent risk factors for LFE in OVCF patients by analyzing their baseline data; second, to compare residual pain and inflammatory marker levels between different patient groups stratified by postoperative edema after percutaneous vertebroplasty (PVP); and third, to investigate the influence of age on postoperative indicators using age-based subgroup analysis. These efforts aim to provide an evidence-based reference for optimizing clinical treatment strategies for OVCF.

## Materials and methods

### *Participants*

This retrospective study included 360 patients with OVCF who underwent PVP at Xi'an Central Hospital between January 2020 and March 2025. Based on preoperative MRI findings, patients were categorized into the lumbar fascial edema group (LFE group, n=131) and the non-LFE group (NLFE, n=229). This study was approved by the Medical Ethics Committee of Xi'an Central Hospital.

Inclusion criteria: (1) female patients aged >55 years and male patients aged >60 years; (2) primary diagnosis of osteoporotic thoracic or lumbar compression fracture confirmed by thoracic and lumbar MRI; (3) normal mental status without communication barriers; (4) complete medical records. Exclusion criteria: (1) recent onset of edema secondary to surgery or other causes; (2) history of localized lumbar massage therapy; (3) comorbid cardiovascular, renal, or hepatic diseases; (4) concurrent neoplastic diseases, infectious diseases, or congenital spinal deformities; (5) presence of secondary osteoporosis.

### *Surgical methods*

All 360 patients underwent PVP, performed by physicians with an associate senior title or higher. Preoperatively, intravenous access was established, followed by induction of general anesthesia. Patients were placed in the prone position with a transverse pillow placed under the chest to achieve hyperextension of the thoracolumbar spine.

Under C-arm fluoroscopic guidance, the pedicles of the fractured vertebrae was localized, ensuring alignment of the superior and inferior endplates of the fractured vertebra and equal spacing of the bilateral pedicles from the spinous process. The surgical site was then marked and routine disinfection and draping was performed. A 0.3-0.5 cm skin incision was made. Under fluoroscopic guidance, a percutaneous puncture was performed along the pedicle at an appropriate angle, advancing the needle along the pedicle into the fractured vertebra until the tip reached the posterior edge of the vertebral body. The C-arm was adjusted to confirm the needle tip position: midline on the anteroposterior view and anterior 1/3 of the vertebral body on the lateral view.

The stylet was removed, and bone cement (Heraeus Medical Ltd., Model No. 884108; Approval No.: Guomaozhixin20183651269) was injected into the fractured vertebra under real-time fluoroscopy. The injection continued until the cement diffused along the trabecular

spaces to the cortical bone, with the cement edge presenting a burr-like appearance. The needle was withdrawn after initial cement hardening. The surgical field was re-sterilized, and a sterile dressing was applied to complete the procedure.

Throughout the operation, patients' vital signs were continuously monitored, and prompt interventions were implemented in case of adverse events.

*Observation indicators*

Baseline data collection: The following baseline parameters were recorded: age, sex, height, weight, body mass index (BMI), bone mineral density (BMD), fracture segment, trauma history, lumbar instability, presence of old vertebral compression fractures, and degree of fracture compression. Vertebral compression fractures were classified based on the percentage of vertebral height loss: mild (20%-25%), moderate (26%-40%), and severe (>40%).

Pain and lumbar dysfunction: at 3 and 6 months postoperatively, pain intensity was assessed using the numerical rating scale (NRS) [10], and lumbar spine function was evaluated using the modified Oswestry Disability Index (ODI) [11]. The NRS is a patient-reported scale ranging from 0 to 10, with higher scores indicating more severe pain. The modified ODI has a total score range of 0-50, where lower scores correspond to better lumbar spine function.

Incidence of residual pain [12]: The incidence of residual pain in both groups was calculated at 3 and 6 months after surgery. Residual pain was defined as an NRS score ≥4, a threshold typically indicating intolerable pain requiring intervention (e.g., medication adjustment) based on clinical criteria.

Detection of inflammatory factors: At 3 and 6 months postoperatively, 5 mL of fasting venous blood was collected from the elbow in each patient. The blood samples were centrifuged at 3,000 r/min for 15 minutes, and the supernatant was collected. Serum C-reactive protein (CRP) and interleukin-6 (IL-6) levels were measured using enzyme-linked immunosorbent assay (ELISA), following the manufacturer's instructions.

*Statistical analysis*

All statistical analyses were performed using SPSS 26.0 software. Measurement data were expressed as mean ± standard deviation (±s). Between-group comparisons were conducted using the independent samples t-test, while within-group comparisons across different time points were analyzed using one-way analysis of variance (One-way ANOVA). Count data were presented as frequencies and percentages [n (%)], and differences were evaluated using the Pearson chi-square test. Multivariate logistic regression analysis was applied to identify independent risk factors, and receiver operating characteristic (ROC) curves were generated to assess their diagnostic value. A *P*-value <0.05 was considered statistically significant.

## Results

*Comparison of baseline data between the two groups*

As shown in **Table 1**, no significant differences were observed between the LFE and NLFE groups in terms of sex, height, weight, BMI, BMD, fracture segment, or degree of fracture compression (all P>0.05).

*Analysis of risk factors for LFE in OVFR patients*

As shown in **Table 2**, univariate analysis revealed that, compared with the NLFE group, the LFE group had significantly older age, higher proportion of trauma history, greater incidence of lumbar instability, and more frequent history of old vertebral compression fractures (all P<0.05). The variable assignments for each risk factor are presented in **Table 3**. Multivariate logistic regression analysis identified age, trauma history, lumbar instability, and old vertebral compression fractures as independent risk factors for LFE in patients with OVCF (**Table 4**).

*ROC curve analysis of LFE-related risk factors*

ROC curve analysis was performed for the identified risk factors, including age, trauma history, lumbar instability, and history of old vertebral compression fractures. The results demonstrated that age (AUC=0.845), trauma history (AUC=0.654), lumbar instability (AUC=0.652), and history of old vertebral compression frac-

**Table 1.** Comparison of baseline data between the two groups

| | LFE group (n=131) | NLFE group (n=229) | $t/\chi^2$ | *P* |
|---|---|---|---|---|
| Age (yrs) | | | 9.675 | <0.001 |
| <70 | 22 | 158 | | |
| ≥70 | 109 | 71 | | |
| Gender | | | 0.325 | 0.569 |
| Male | 56 | 105 | | |
| Female | 75 | 124 | | |
| Height (cm) | 162.55±5.37 | 163.43±4.39 | 1.684 | 0.093 |
| Weigh (kg) | 61.37±7.35 | 61.10±8.33 | 0.309 | 0.58 |
| BMI (kg/m$^2$) | 23.21±2.41 | 22.82±2.55 | 1.424 | 0.155 |
| Bone density (T value) | -2.60±0.39 | -2.61±0.33 | 0.259 | 0.796 |
| Vertebral fracture site | | | 0.231 | 0.631 |
| Thoracic | 47 | 88 | | |
| Lumbar | 84 | 141 | | |
| Degree of fracture compression | | | 1.779 | 0.411 |
| Mild | 85 | 143 | | |
| Moderate | 30 | 65 | | |
| Severe | 16 | 21 | | |

Note: BMI, body mass index; LFE, lumbar fascial edema; OVCF, osteoporotic vertebral compression fracture.

**Table 2.** Univariate analysis of risk factors associated with LFE in OVCF patients

| | LFE group (n=131) | NLFE group (n=229) | $\chi^2$ | *P* |
|---|---|---|---|---|
| Trauma | | | 31.699 | <0.001 |
| Yes | 89 | 85 | | |
| No | 42 | 144 | | |
| Lumbar instability | | | 57.450 | <0.001 |
| Yes | 46 | 11 | | |
| No | 85 | 218 | | |
| Prior vertebral compression fractures | | | 20.388 | <0.001 |
| Yes | 89 | 99 | | |
| No | 42 | 130 | | |

Note: LFE, lumbar fascial edema; OVCF, osteoporotic vertebral compression fracture.

**Table 3.** Assignment table

| Risk factors | Assignments |
|---|---|
| Age (yrs) | 0= Age <70 |
| | 1= Age ≥70 |
| Trauma | 0= No |
| | 1= Yes |
| Lumbar instability | 0= No |
| | 1= Yes |
| Prior vertebral compression fractures | 0= No |
| | 1= Yes |

tures (AUC=0.624) all demonstrated diagnostic value for LFE occurrence, with age showing the highest diagnostic performance. Details are shown in **Figure 1**.

*Comparison of NRS and ODI between the two groups before and after surgery*

As shown in **Figure 2**, there were no significant differences in NRS or ODI scores between the two groups preoperatively (P>0.05); both NRS and ODI scores significantly decreased in both groups at 3 and 6 months postoperatively. Additionally, at both time points, NRS and ODI scores in the LFE group were significantly higher than those in the NLFE group (all P<0.05).

*Comparison of residual pain incidence between the two groups at postoperative 3 and 6 months*

As shown in **Table 5**, at 3 and 6 months postoperatively, the incidence of residual pain

**Table 4.** Multivariate logistic regression analysis of risk factors for LFE in OVCF patients

| | β | StdError | OR | 95% CI | P |
|---|---|---|---|---|---|
| Age | -2.476 | 0.318 | 0.084 | 0.045-0.157 | <0.001 |
| Trauma | -1.267 | 0.292 | 0.282 | 0.159-0.499 | <0.001 |
| Lumbar instability | -2.284 | 0.440 | 0.102 | 0.043-0.241 | <0.001 |
| Prior vertebral compression fractures | -0.880 | 0.291 | 0.415 | 0.234-0.734 | 0.002 |

Note: LFE, lumbar fascial edema; OVCF, osteoporotic vertebral compression fracture.

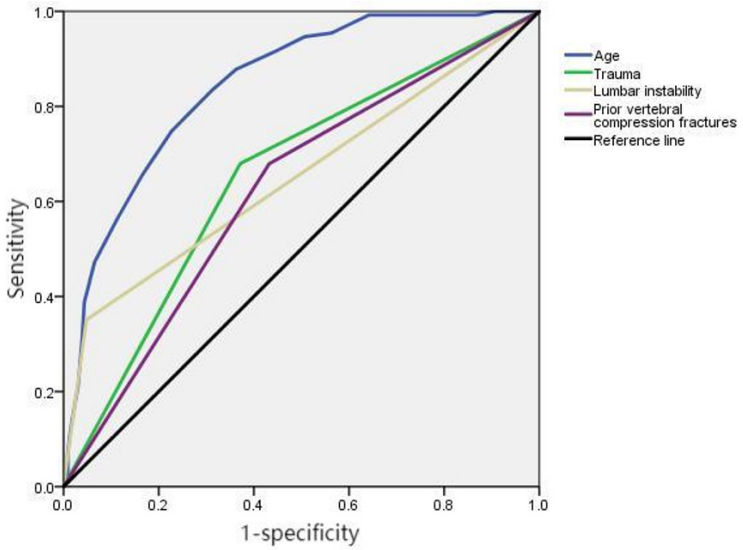


**Figure 1.** ROC curve analysis for LFE related risk factors. Notes: ROC, receiver operating characteristic; LFE, lumbar fascial edema.

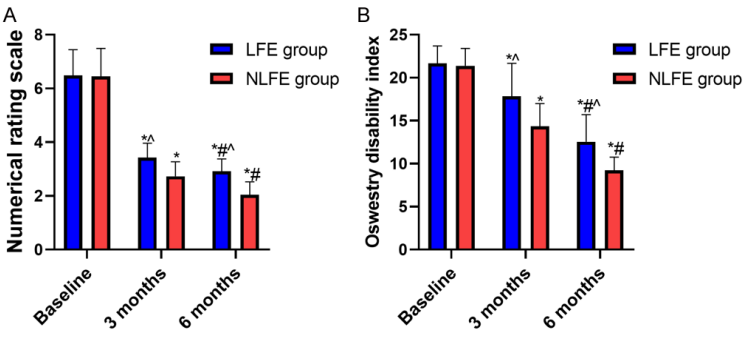


**Figure 2.** Comparison of NRS (A) and ODI (B) scores between the LFE and the NLFE groups before and after treatment. Notes: LFE, lumbar fascial edema; NLFE, non-lumbar fascial edema; NRS, numerical pain scale; ODI, Oswestry disability index. *P<0.05, compared with baseline value; #P<0.05 compared with postoperative 3 months; ^P<0.05, compared with NLFE group.

(defined as NRS ≥4) significantly decreased in both groups. Moreover, at both 3 and 6 months after surgery, the incidence of residual pain in the LFE group was significantly higher than that in the NLFE group (all P<0.05).

*Comparison of CRP, IL-6 levels between the two groups before and after surgery*

As shown in **Figure 3**, there were no significant differences in CRP and IL-6 levels between the two groups preoperatively (P>0.05). At 3 and 6 months postoperatively, CRP and IL-6 levels in both groups showed significant reductions compared with baseline. Moreover, at both time points, the expression levels of CRP and IL-6 were significantly higher in the LFE group compared to the NLFE group (all P<0.05).

*Comparison of NR, ODI and residual pain incidence between different age groups*

As shown in **Figure 4** and **Table 6**, NRS and ODI scores in both age groups decreased significantly from preoperative to postoperative 3 and 6 months. Notably, the NRS and ODI scores in patients aged ≥70 years were significantly higher than those in patients aged <70 years at all time points (all P<0.05). Furthermore, in patients aged ≥70 years, the incidence of residual pain (NRS ≥4) significantly decreased from 3 to 6 months postoperatively (P<0.05). However, the incidence of residual pain in patients ≥70 years was significantly higher than those

**Table 5.** Comparison of residual pain incidence between the two groups at postoperative 3 and 6 months

| Group | n | Residual Pain incidence | | $\chi^2$ | *P* |
|---|---|---|---|---|---|
| | | 3 months | 6 months | | |
| LFE group | 131 | 54 (41.22) | 9 (6.87) | 42.319 | <0.001 |
| NLFE group | 229 | 10 (4.37) | 1 (0.44) | 7.545 | 0.006 |
| $\chi^2$ | | 76.937 | 12.770 | | |
| *P* | | <0.001 | <0.001 | | |

Note: LFE, lumbar fascial edema.

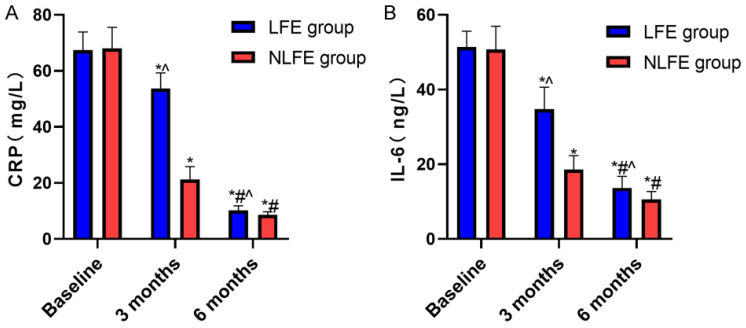


**Figure 3.** Comparison of CRP (A) and IL-6 (B) levels between the LFE and the NLFE groups before and after treatment. Notes: LFE, lumbar fascial edema; NLFE, non-lumbar fascial edema; CRP, C-reactive protein; IL, interleukin. *P<0.05, compared with baseline value; #P<0.05 compared with postoperative 3 months; ^P<0.05, compared with NLFE group.

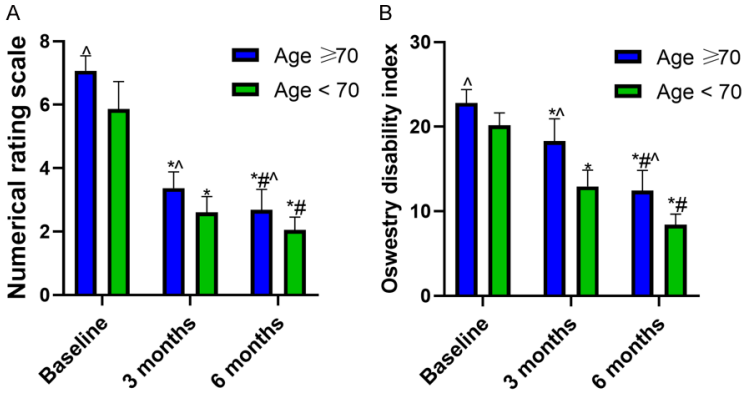


**Figure 4.** Comparison of NRS (A) and ODI (B) scores between patients of different age groups before and after treatment. Notes: NRS, numerical pain scale; ODI, Oswestry disability index. *P<0.05, compared with baseline value; #P<0.05 compared with postoperative 3 months; ^P<0.05, compared with age <70 group.

aged <70 years at both 3 and 6 months postoperatively (P<0.05).

*Comparison of CRP and IL-6 levels between different age groups*

As shown in **Figure 5**, CRP and IL-6 levels in both age groups significantly decreased from the preoperative period to 3 and 6 months postoperatively (all P<0.05). At all time points, patients aged ≥70 years had significantly higher CRP and IL-6 levels than those aged <70 years (all P<0.05).

## Discussion

Osteoporotic vertebral compression fracture (OVCF) is a common manifestation of osteoporosis, affecting approximately one-third of women and one-fifth of men over 50 years of age, and posing a serious threat to the health of middle-aged and elderly individuals [13]. LFE is a frequent complication of OVCF, typically detected by MRI [14]. In osteoporotic patients, OVCF induced by minor trauma or strenuous activity may be accompanied by injury to the lumbar fascia. Under the influence of various factors, non-specific inflammatory changes can develop, leading to edema and degeneration and contributing to pain and other clinical symptoms, which can seriously impair postoperative recovery [15]. In addition, residual pain after vertebroplasty is another important factor affecting patients' postoperative recovery. Therefore, identifying risk factors for LFE in OVCF patients and evaluating its impact on postoperative residual pain are crucial for optimizing surgical treatment and perioperative management strategies.

In this study, univariate and multifactorial logistic regression analyses identified age, history of trauma, lumbar instability, and old vertebral compression fractures as independent risk factors for the development of LFE in OVCF patients. ROC curve analysis showed that these four factors had significant predictive value, with age showing the highest diagnostic performance. This is consistent with the findings reported by Guven et al. [16], Pan et al.

**Table 6.** Comparison of residual pain incidence between patients of different age groups at postoperative 3 and 6 months

| Group | n | Residual Pain incidence | | $\chi^2$ | *P* |
|---|---|---|---|---|---|
| | | postoperative 3 months | postoperative 6 months | | |
| ≥70 | 180 | 64 (4.37) | 10 (0.44)# | 36.900 | <0.001 |
| < 70 | 180 | 0 (0.00) | 0 (0.00) | - | - |
| $\chi^2$ | | 77.838 | 10.286 | | |
| *P* | | <0.001 | 0.001 | | |

#P<0.05, compare with postoperative 3 months.

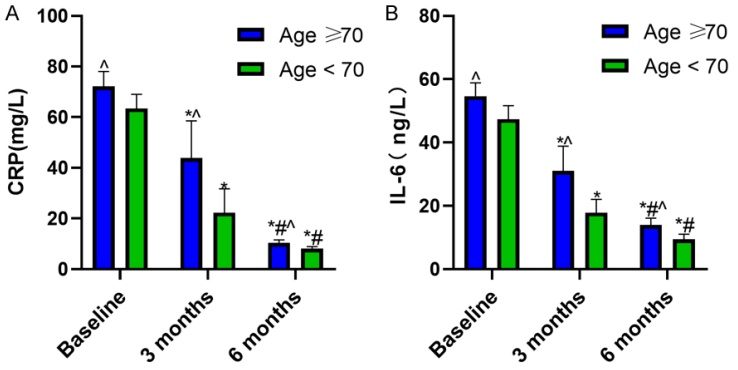


**Figure 5.** Comparison of CRP (A) and IL-6 (B) levels between patients of different age groups before and after treatment. Notes: CRP, C-reactive protein; IL, interleukin. *P<0.05, compared with baseline value; #P<0.05 compared with postoperative 3 months; ^P<0.05, compared with age <70 group.

[17], and Allihien et al. [18], who also demonstrated that age, history of trauma, lumbar instability, and old vertebral compression fractures are important predictors of LFE. The underlying reasons may be as follows: (1) with increasing age, degenerative changes in the lumbar spine progress, and the adaptive capacity of lumbar paraspinal muscles and fascia declines, increasing susceptibility to musculoskeletal and fascial injury [19]; (2) patients with lumbar spine instability and old vertebral compression fractures generally present with greater vertebral bone loss, resulting in more severe OVCF manifestations. Consequently, damage to the lumbar myofascia is more difficult to repair, predisposing to persistent or worsening fascial edema [20]; (3) traumatic injuries to the lumbar region are prone to trigger inflammatory reactions in the myofascia. In elderly patients with osteoporosis, pre-existing lumbar trauma before the onset of OVCF may further compromise spinal mechanics and paraspinal musculature. Following OVCF, these patients are more vulnerable to severe inflammatory reactions, thereby accelerating the development of lumbar fascial edema [21]. Our results are similar to those of Mukai et al. [22] and Abbassi et al. [21], underscoring the importance of age and trauma history in the diagnosis and risk stratification of LFE in OVCF patients.

In this study, postoperative NRS score, ODI score, and the incidence of residual pain were significantly higher in the LFE group than in the NLEF group. Moreover, all three indices were significantly higher in patients aged ≥70 years compared with those aged <70 years. These findings are consistent with previous reports by Luo et al. [15] and Shahi et al. [23], which highlighted the adverse prognostic impact of thoracolumbar fascia injury on OVCF patients. The possible reasons for this are as follows: (1) during percutaneous transluminal vertebroplasty, bone cement injection increases the stiffness of the treated vertebrae and alters stress distribution between the fractured and adjacent vertebrae, which may elevate the risk of postoperative residual low back pain [24]; (2) OVCF-induced pain are more intense, which often masks the pain caused by post-fracture soft tissue injury. Once fracture pain is alleviated postoperatively, pain from residual fascial or soft tissue damage becomes more noticeable [25]; (3) With advancing age, further decline in physical function and the presence of LFE aggravate postoperative lumbar pain, hinder improvement in lumbar joint range of motion, and impair spinal kinematics. Edema-induced mechanical restriction may also limit functional recovery of the lumbar spine [26, 27]. These results suggest that edema caused by lumbar fascial tissue injury can impede postoperative

pain relief and functional recovery. This effect is more pronounced in elderly patients, underscoring the need for targeted perioperative management strategies.

Studies have shown that inflammation plays an important role in the development of osteoporosis, with inflammatory factors IL-6 and CRP contributing to osteoporosis and associated fractures by affecting bone mineral density [28-30]. In addition, muscle tissue injury-related edema is also an important factor in the inflammatory response. Elevated levels of inflammatory factors, such as IL-6 and CRP, can increase vascular permeability, reduce serum albumin and fibrinogen concentrations, and elevate lipoproteins and pro-coagulant factors, thereby increasing the risk of thrombosis and impairing muscle tissue repair [31, 32]. In this study, we compared preoperative and postoperative inflammatory factor levels between the LFE and NLFE groups. Results showed that postoperative CRP and IL-6 levels were significantly higher in the LFE group than in the NLFE group. Additionally, these inflammatory markers were significantly higher in patients aged ≥70 years compared with those <70 years. These findings are consistent with the findings of Long et al. [33] in patients with fracture blisters, and Ding et al. [34] in elderly patients with hip fractures. The possible explanations are as follows: (1) patients in the LFE group exhibited elevated inflammatory factor levels not only due to OVCF but also because of fascial edema, which may be more pronounced with aging; (2) although vertebroplasty can alleviate pain and partially reduce inflammatory response caused by vertebral fracture, it does not directly repair lumbar fascial tissue injury or resolve edema [35]. These results suggest that elevated inflammatory factors may be may be both a consequence and a potential driver of LFE in OVCF patients, possibly contributing to the persistence or progression of fascial edema. In future studies, this factor could be studied to determine its role in LFE.

In summary, LFE in patients with OVCF is closely related to age, trauma history, lumbar instability, and old vertebral compression fractures. Patients with LFE exhibit higher rates of postoperative residual pain, and elevated inflammatory factors may represent a potential mechanism of action.

This study has several limitations. First, it was a single-center retrospective case analysis with a relatively small sample size, which may have introduced selection bias; Second, the use of the NRS as the sole criterion for assessing residual low back pain may lack objectivity; Third, the choice of postoperative 3-6 months as the time points for evaluating residual pain and measuring inflammatory factor levels requires further validation. Future research should involve multicenter studies with large sample size, and extended follow-up periods to better clarify the influencing factors of LFE and postoperative residual pain in OVCF patients.

## Disclosure of conflict of interest

None.

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