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REVIEW

What Factors Contribute to the Poor Prognosis of Conservative Treatment for Osteoporotic Vertebral Compression Fracture (OVCF): A Systematic Review

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Background: Osteoporotic vertebral compression fracture (OVCF) is a prevalent fragility fracture in older adults, often managed with conservative treatment. However, elderly patients are particularly prone to poor prognoses under conservative management, which warrants early identification. This systematic review aims to summarize the risk factors for poor long-term prognosis in older OVCF patients receiving conservative treatment, facilitating early recognition during initial diagnosis.

Methods: This systematic review followed the PRISMA statement criteria and searched the literature until June 2025. The inclusion criteria were patients with OVCFs who underwent conservative treatment only and had at least three months of follow-up. Poor prognoses include no pain relief, dysfunction, and complications such as collapse, nonunion, and kyphosis deformity. The Newcastle–Ottawa Scale (NOS) was used to screen for articles with a low risk of bias.

Results: This systematic review included 26 articles that met our inclusion criteria. These articles involved 4319 participants (80.2% female), with an average age of 72.91 years. OVCF patients with advanced age, previous spine fracture and steroid medication uses had a poor prognosis. On X-ray, poor prognoses are associated with thoracolumbar involvement, vertebral instability, middle–column injury, initial fracture parameters, and specific fracture morphology. Additionally, specific MRI signal changes (such as diffuse low-intensity signals on T2WI, linear black sign on STIR) and fatty degeneration of the paravertebral muscle are also risk factors.

Conclusion: All methods, including nonimaging, X-ray, and magnetic resonance imaging (MRI), can effectively predict the poor prognosis for OVCF patients treated conservatively. Early identification of these geriatric-specific risk factors can optimize treatment selection for elderly individuals, mitigating functional decline and improving quality of life.

Keywords: osteoporotic vertebral compression fracture, OVCF, conservative treatment, poor prognosis, risk factors, MRI, X-ray

Introduction

Osteoporotic vertebral compression fractures (OVCFs) are among the most common fragility fractures in older adults, predominantly affecting the geriatric population.[1] Current treatments for OVCFs fall into two main categories: conservative treatment involving strict bed rest, pain medication, and wearing braces to relieve symptoms and restore movement; and surgical intervention, including vertebroplasty and internal fixation surgery, which are widely used in clinical practice.[2,3]

Conservative treatment can effectively relieve symptoms in most patients.[2] However, some patients may still experience complications such as progressive vertebral collapse, nonunion, nerve injury and kyphotic deformity.[4]

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These complications can cause increased pain and limited mobility, significantly reducing the quality of life and even shortening the life expectancy in elderly individuals.[5–9] Surgical interventions, such as vertebroplasty, are effective in relieving pain and significantly reducing these complications.[10] However, such interventions carry the risk of other complications, such as bone cement leakage, infection, and pulmonary embolism.[11] In addition, indiscriminately performing surgery on OVCF patients will inevitably increase medical costs and result in overmedication.[12]

Early surgical intervention has shown greater effectiveness than later intervention.[13] Identifying the risk factors associated with poor prognosis with elderly OVCF patients treated conservatively in the early stages can help more appropriate treatment options, such as vertebroplasty.[14]

Despite prior systematic reviews on prognostic factors of conservative OVCF treatment,[15,16] critical gaps persist: (1) outdated literature searches (excluding 2020–2025 evidence); (2) focus on single outcomes while omitting patient-reported outcomes (pain, disability or health-related quality of life); (3) lack of strict restriction on "risk factor assessment timing" (ie, detectability at initial diagnosis), limiting clinical utility.

Therefore, in this systematic review, we searched for articles reporting poor prognoses in elderly OVCF patients treated conservatively. The core objective of this study is to systematically summarize the risk factors for long-term poor prognosis (persistent pain, functional disability, vertebral collapse, nonunion, and kyphotic deformity) in elderly OVCF patients receiving conservative treatment, and to provide evidence-based support for early risk identification during initial diagnosis, thereby facilitating individualized treatment decision-making for this population.

Materials and Methods

Research Strategy

Following the PICO principle,[17] we identified the search terms to be used in the literature search. The patients (P) under investigation were elderly patients with OVCFs. Intervention (I) was strictly limited to conservative treatment, excluding invasive procedures, so there was no comparison (C) group. The outcomes (O) included low back pain; dysfunction scores; and complications such as vertebral collapse, kyphosis, pseudarthrosis, and neurologic manifestations.

Literature Search

The search was carried out in the following databases: PubMed, Medline, Cochrane, and Web of Science. The literature search was conducted up to June 2025 and there were no restrictions on publication type. Given that much literature does not explicitly mention conservative treatment or specific therapies, strict keyword restrictions for these could miss substantial relevant studies. Thus, no conservative treatment-related keyword limits were applied during retrieval; surgical studies were excluded in preliminary screening. The search terms included osteoporosis, vertebral compression fracture, nonunion, vertebral collapse, kyphosis and neurological deficit. The detailed search formulas and strategies are provided in Supplementary Table 1. Our study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) standards.[18,19]

Criteria for Inclusion and Exclusion

The literature needed to fulfill the following criteria for inclusion: (1) Elderly patients with a clinical and radiological diagnosis of OVCF. (2) Patients who received only conservative treatment. (3) A minimum of three months of follow-up was conducted. (4) Studies with valid outcome indicators such as complications or symptoms. (5) Risk factors must be collectable at the early stage of fracture. The exclusion criteria for articles were as follows: (1) Cross-sectional studies, case reports, cadaveric studies, experimental studies, and editorials or reviews. (2) Patients without osteoporosis. (3) Vertebral fractures caused by high-energy violent injuries. (4) Patients treated with surgical procedures. (5) Patients with previous surgery at the vertebral body.

Data Extraction

The screening of the literature to determine the articles that met the criteria for inclusion was accomplished by evaluating all titles and abstracts initially and independently assessing each article by two reviewers, Ao J.T. and Xu Z.N. In cases of disagreement, the final determination of whether to include the article was made by a third author, Wu J.Y. If evaluating the titles and abstracts of the research papers did not provide enough information to make a decision about acceptance or rejection, the full text was analyzed in detail. Finally, the full texts of the screened articles were carefully reviewed to exclude any studies that did not meet the inclusion criteria, and the authors assessed the bibliographies of the reviewed studies to find missing studies. The data that were extracted consisted of the author's name, the year of publication, the country where the study was conducted, the design of the study, the characteristics of the population involved, the length of the follow-up period, the methods used for imaging detection, the statistical tests employed, the statistical parameters (such as OR, β, and p value), the outcomes observed, and the associated risk factors.

Article Quality Assessment

We evaluated the quality of every study included by utilizing the Newcastle–Ottawa Scale (NOS).[20] The NOS is a tool used to evaluate the bias of studies, employing three classifications: selection (four points), comparability (two points) and outcome (three points). Studies that received scores ranging from 7 to 9 were deemed to be of high quality, whereas studies scoring between 4 and 6 were associated with a high risk of bias. Additionally, studies with scores ranging from 0 to 3 were found to have an exceedingly high risk of bias. For quality assurance, only studies scoring 7--9 were included.

Results

Study Selection

After eliminating duplicates, the initial screening process was conducted on 1895 distinct articles out of the 3336 articles obtained from the literature search. After reviewing the titles and abstracts, a total of 75 articles were selected for full-text screening and data extraction. In the end, a total of 26 articles[21–46] that satisfied the inclusion criteria were identified and incorporated into this comprehensive review. Figure 1 shows the flow diagram summarizing the study selection process.

Study Characteristics

All 26 studies included in this systematic review were written in English. The majority of the studies were conducted in Japan (14 articles), with the remaining studies conducted in Korea (4 articles), India (2 articles), Spain (2 articles), China (1 article), Israel (1 article), Italy (1 article) and Germany (1 article). These articles were published between 2005 and 2025. The studies involved a total of 4319 participants, 80.2% of whom were female, and the average age was 72.91 years. The sample sizes varied between 35 and 551 participants, with mean follow-up periods ranging from 3 to 27.5 months. Basic information, including authors, year, country, study design, sample size, characteristics such as age and sex, follow-up duration, image detection methods, risk factors and the NOS score, is presented in Table 1.

Outcomes

The core risk factors for poor prognosis in elderly OVCF patients receiving conservative treatment can be grouped into three categories: (1) non-imaging findings: advanced age, prior vertebral fracture, history of steroid use; (2) X-ray: vertebral instability, middle-column injury, thoracolumbar involvement and specific fracture types; and (3) specific MRI signal changes and paraspinal muscle fatty degeneration. Early recognition of these factors at diagnosis may help optimize treatment selection and reduce functional decline in elderly patients.

Non-Imaging Findings

A total of 9 articles addressed risk factors for conservative treatment of OVCFs on the basis of nonimaging findings, including age, sex, history of steroid medication use, previous spine fracture, and total 25(OH)D level. These article details are presented in Table 2.

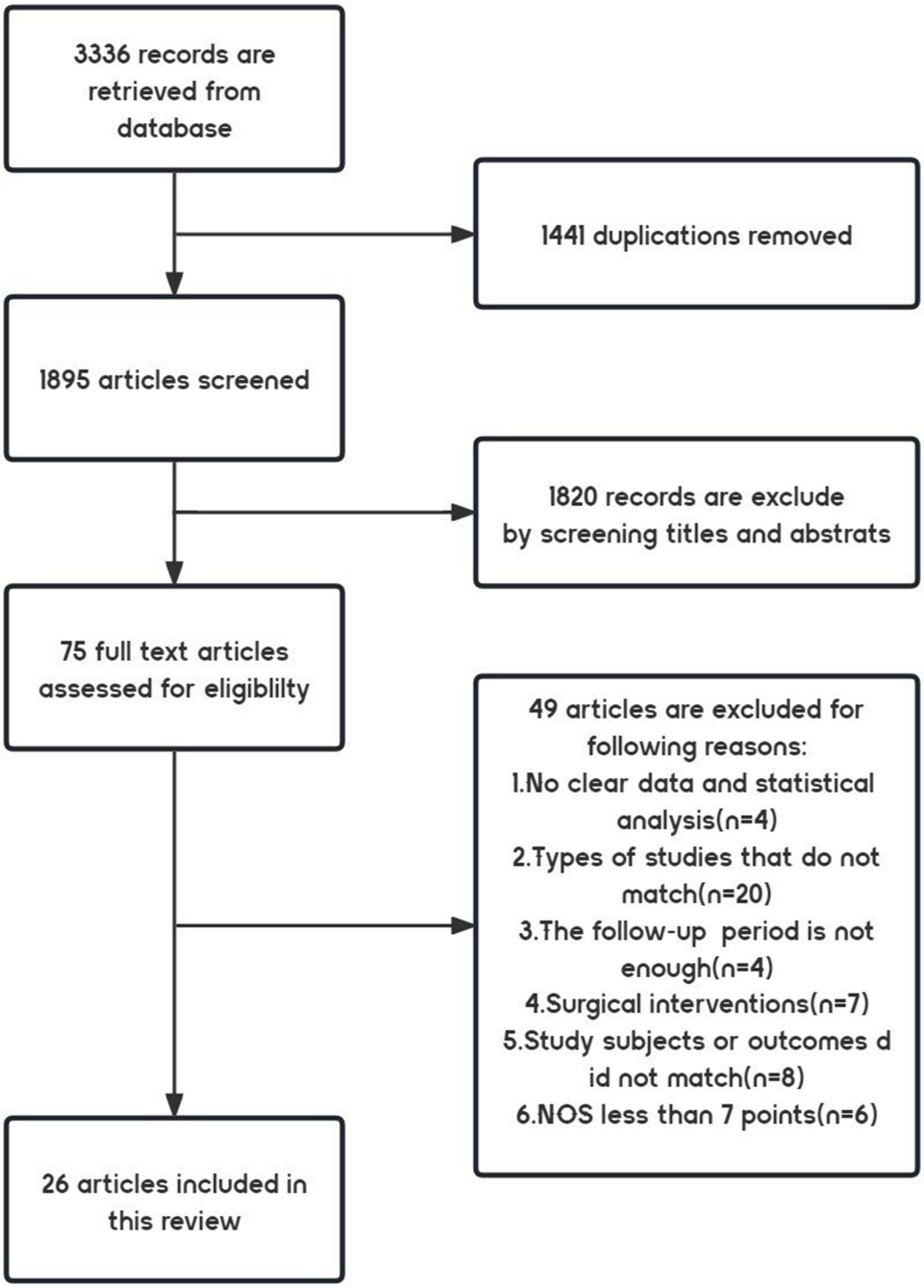

Figure 1 Diagram of the study selection process following the PRISMA principles.

Hoshino, M et al[23] conducted a prospective multicenter study with 362 elderly patients who were diagnosed with OVCFs and who received conservative treatment to evaluate the influence of demographic factors and prior medical history on Short Form-36 (SF-36) questionnaire scores at 6 months.

The SF-36 questionnaire, created by the World Health Organization, is a commonly utilized tool for assessing health conditions. It offers two overall scores: the physical component summary (PCS) and the mental component summary (MCS). Quality of life related to physical or mental health was assessed via a 0–100 scale, where higher scores indicate better quality of life.[47] Previous use of steroids was associated with lower MCS scores on the SF-36 and a greater likelihood of prolonged back pain and vertebral collapse.[23] The findings also suggested that female sex and age over 75

Table 1 Basic Information Extracted From the Studies

Authors, Country, Year	Study Design	Population Characteristics (Unit of Age: Years)	Mean Follow-up	Risk Factors	NOS
Abe et al, Japan, 2018[21]	Retrospective case–control	154 F/M=132/22 age=81.2	24 weeks	(1) VI; (2) Confined high intensity	7
Ahmadi et al, Japan, 2019[22]	Prospective multicenter	153 F/M=125/28 age=78.5	6 months	(1) Confined high intensity; (2) Previous spine fracture	7
Hoshino et al, Japan, 2013[23]	Prospective multicenter	362 F/M=303/59 age=76.3	6 months	(1) Middle column injury; (2) Female; (3) Advanced age; (4) Previous use of steroid	8
Jeon et al, South Korea, 2021[24]	Retrospective	55 F/M=39/16 age=75.04±5.83	>6 months	(1) Fatty degeneration of the paraspinal muscle; (2) Initial vertebral collapse	7
Kim et al, South Korea, 2016[25]	Retrospective	35 F/M=30/5 age=71.86	12 weeks	Age	7
Lee et al, South Korea, 2017[26]	Retrospective	82 F/M=64/18 age=69.27±10.33	6 months	Necrotic lesion area	7
Muratore et al, Italy, 2020[27]	Retrospective	180 F/M=138/42 age=77	5 months	(1) TL junction; (2) Swelling type; (3) Bow-shaped type; (4) Linear black signal pattern	7
Omar et al, Germany, 2021[28]	Retrospective	44 F/M=35/9 age=71.51	18.18 months	SSIR	7
Omi et al, Japan, 2014[29]	Prospective	56 F/M=48/8 age=77.5	6 months	(1) Non-homogenous high signal; (2) Linear black signal	7
Park et al, South Korea, 2018[30]	Retrospective case–control	60 F/M=NR (1) age=73.5±8.5; (2) age=71.9±9.7	3 months	(1) Initial height loss; (2) Mid portion type fracture	8
Patil, S. and A.M. NeneIndia, 2014[31]	Retrospective	64 F/M=33/31 age=64	27.5 months	(1) TL junction; (2) Superior endplate fracture	7
Smorgick et al, Israel, 2020[32]	Retrospective	124 F/M=86/38 age=69±9.6	14 months	Negative results	7
Sugita et al, Japan, 2005[33]	Retrospective	73 F/M=58/15 age=75	23.4 months	Swelled-front, Bow-shaped, Projecting type	7
Suzuki et al, Japan, 2009[34]	Retrospective	107 F/M=72/35 age=75.5	12 months	Severe fracture	7
Suzuki et al, Japan, 2010[35]	Prospective	107 F/M=72/35 (1) age=73.5±11.9; (2) age=77.7±11.6	12 months	Previous spine fracture	8

(*Continued*)

Table 1 (Continued).

Authors, Country, Year	Study Design	Population Characteristics (Unit of Age: Years)	Mean Follow-up	Risk Factors	NOS
Toyoda et al, Japan, 2021[36]	Prospective multicenter	Union: 407 F/M=344/63 age=76.3±6.9 Delayed Union: 101 F/M=80/21 age=78.5±6.7	6 months	(1) Middle column injury; (2) TL junction; (3) Confined high intensity and diffuse low intensity	9
Toyoda et al, Japan, 2017[37]	Prospective multicenter	128 F/M=107/21 age=78	6 months	Previous spine fracture	7
Tsujio et al, Japan, 2011[38]	Prospective multicenter	350 F/M=296/54 age=75.9	6 months	(1) Middle column injury; (2) TL junction; (3) Confined high, diffuse low intensity	9
Takahashi et al, Japan, 2022[39]	Prospective multicenter	153 F/M=125/28 age=NR	6 months	(1) Age; (2) T-score; (3) Anterior height ratio; (4) High, diffuse low intensity	8
Okuwaki et al, Japan, 2022[40]	Retrospective	70 patients F/M=NR age=79.4±7.3	6 months	(1) 25(OH)D level (2) VI	7
Viswanathan et al, India, 2022[41]	Prospective	77 F/M=62/15 (1) age=67.9±9.1 (2) age=70.4±7.6 (3) age=72.3±7.9	6 months	(1) Initial vertebral height loss; (2) Initial segmental Cobb angle; (3) PLC injury; (4) Confined high intensity, diffuse low intensity	7
Chen SW et al, China, 2024[42]	Prospective	161 F=161 age=72.71±5.61	6–12 months	TL junction (T10-L2)	8
Ruiz et al, Spain, 2023[43]	Retrospective case-control	56 F/M=48/8 age=72.6±1.2	19 months	(1) Age; (2) HU; (3) Difference PVH loss	8
Gutierrez et al, Spain, 2023[44]	Retrospective case-control	489 F/M=351/138 age=74.6±10.4	21 weeks	(1) Sex (male); (2) A3 type; (3) TL junction	8
Ogon I et al, Japan, 2023[45]	Prospective	150 F=150 age=79.1±7.4	3 months	D*(IVIM)	7
Wakao N et al, Japan, 2023[46]	Retrospective	551 F/M=399/152 age=81.8±7.6	1 year	Posterior wall injury	7

Abbreviations: F/M, female/male; NR, not reported; MRI, magnetic resonance imaging; CT, computed tomography; VI, vertebral instability; SSIR, spinal signal intensity ratio; TL, thoracolumbar; PLC, posterior ligamentous complex; 25(OH)D, 25-hydroxy vitamin D; PVH, posterior vertebral height; HU, Hounsfield unit; D*, perfusion-related diffusion; IVIM, intravoxel incoherent motion.

years are significant predictors of lower scores on the physical PCS of the SF-36. However, in the study by Gutierrez-Gonzalez R et al[44] male sex was identified as a risk factor for fracture progression, with male patients tending to exhibit more significant vertebral height loss.

Kim, H. J. et al[25] investigated the relationship between age and functional limitations in a prospective observational study of 35 patients with OVCFs. The findings revealed that age was a significant predictor of higher Oswestry Disability Index (ODI) scores at 12 weeks, which indicate more severe functional impairment following vertebral fracture. The ODI is an accurate and valid patient-reported assessment tool for evaluating low back pain and related disability, with higher scores reflecting more pronounced dysfunction.[48] Advanced age was also reported as a risk factor for nonunion in a study

Table 2 Risk Factors Based on Nonimaging Findings

Author Year	Risk Factor	Outcomes (Corresponding Risk Factors)	Statistical Test Methods	OR [95% CI] or β	P value
Ahmadi et al, 2019[22]	Previous vertebral fracture	Back pain	Multivariate logistic regression	2.43 [1.01–5.89]	0.04
Hoshino et al, 2013[23]	(1) Female sex; (2) Advanced age (>75); (3) Previous use of steroids	(1) SF-36 PCS ≤ 40(Female); (2) SF-36 PCS ≤ 40(Age); (3) SF-36 MCS ≤ 40(Steroids use); (4) Prolonged back pain (Steroids use); (5) Vertebral collapse (Steroids use)	Multivariate logistic regression	(1) 2.44 [1.27–4.76] (2) 2.52 [1.50–4.25] (3) 3.55 [1.74–7.25] (4) 2.13 [1.02–4.44] (5) 2.93 [1.43–6.00]	<0.05
Kim et al, 2016[25]	Age	ODI	Multivariate hierarchical regression	β=0.72	0.002
Suzuki et al, 2010[35]	Previous spine fracture	(1) Von Korff disability score; (2) Hannover ADL score; (3) EQ-5D	ANOVA, Mann–Whitney test	N/A	(1) 0.009 (2) 0.019 (3) 0.008
Toyoda et al, 2017[37]	Previous spine fracture	VAS	Fisher's exact test	N/A	<0.017
Takahashi et al, 2022[39]	(1) Age; (2) T-score	Nonunion	Multivariate logistic regression	(1) 1.056 [1.009–1.106] (2) 0.983 [0.973–0.995]	(1) 0.018 (2) 0.006
Okuwaki et al, 2022[40]	25(OH)D	Collapse rate progression	Multiple linear regression	β=−0.298	0.032
Ruiz et al, 2023[43]	Age	Vertebral collapse	Multivariate logistic regression	1.12 [1.02–1.22]	0.014
Gutierrez et al, 2023[44]	Sex (male)	Progression fracture	Multivariate logistic regression	1.583 [1.001–2.501]	0.049

Abbreviations: 25(OH)D, 25-hydroxy vitamin D; SF-36, Short Form-36; PCS, physical component summary; MCS, mental component summary; ODI, Oswestry Disability Index; ADL, activities of daily living; EQ-5D, EuroQol five-dimensional questionnaire; VAS, visual analog scale; ANOVA, analysis of variance; OR, odds ratio; β, standardized regression coefficient; N/A, not applicable.

by Shinji T et al[39] and as a risk factor for vertebral collapse in a study by Ruiz S. F et al.[43] In addition, lower T-scores are statistically correlated with nonunion.[39] Nonunion in this study was defined as the presence of a visible intravertebral cleft (IVC) or segmental mobility on dynamic plain radiographs at the six-month follow-up. This mobility is indicated by a segment Cobb angle change of more than 5 degrees between the supine and weight-bearing positions.

At the 12-month follow-up, Suzuki N et al[35] found that compared with elderly patients without previous fractures, patients with a history of vertebral compression fracture had significantly poorer disability scores according to the von Korff disability scale, Hannover activities of daily living (ADL) score, and quality of life (QoL) as measured by the EuroQol five-dimensional questionnaire (EQ-5D). The von Korff score contains two parts to measure pain intensity or disability.[49] The Hannover ADL score is used to evaluate musculoskeletal disorders,a critical indicator of self-care ability in elderly patients.[50] The EQ-5D is a tool for measuring health-related QoL that ranges from 0 (death) to 1 (full health).[51]

Toyoda, H et al[37] identified different patterns of back pain progression in elderly OVCF patients. The group that exhibited persistent severe pain had the worst prognosis. The present study employed hierarchical cluster analysis and noted that the worst prognosis group included a considerably greater percentage of patients with previous spine fractures, indicating that previous spine fractures are a risk factor for persistent severe pain in patients with OVCFs treated conservatively. Ahmadi et al[22] also reported similar results and noted that previous vertebral fractures were a risk factor for back pain, as indicated by higher visual analog scale (VAS) scores.

Okuwaki S et al[40] collected serum levels of total 25(OH)D from patients with OVCFs and concluded that low levels of 25(OH)D were a significant risk factor for the progression of vertebral collapse. This is the only article that analyzes the relationship between laboratory results and the poor prognosis of OVCFs in geriatric cohorts.

X-Ray Findings

A total of 17 articles incorporated X-ray findings into the risk factor analysis. The detailed research results are presented in Table 3.

Two of the included articles identified vertebral instability (VI) as a risk factor.[21,40] In the study by Abe, T. et al[21] the VI was defined as the difference in the vertebral wedging angle between standing and supine positions. The vertebral wedging angle was calculated by determining the Cobb angle between the superior and inferior endplates. VI greater than

Table 3 Risk Factors Based on X-Ray Findings

Author Year	Risk Factor	Outcomes	Statistical Test Methods	OR [95% CI] or β	P value
Abe et al, 2018[21]	VI	Delayed union	Multivariate logistic regression	1.3 [1.0–1.4]	0.002
Hoshino et al, 2013[23]	Middle column injury	1. SF-36 PCS ≤ 40; 2. Reduced ADL; 3. Prolonged back pain; 4. Vertebral collapse	Multivariate logistic regression	1. 1.86 [1.04–3.32] 2. 2.24 [1.25–4.03] 3. 1.70 [1.01–2.86] 4. 2.45 [1.48–4.03]	<0.05
Jeon et al, 2021[24]	Initial vertebral collapse	Vertebral collapse	Multiple linear regression	β=−0.291	0.013
Muratore et al, 2020[27]	1. TL junction; 2. Swelling type; 3. Bow-shaped type	Vertebral collapse	Univariate logistic regression	1. 4.06 [1.62–10.16] 2. 8.75 [2.91–26.29] 3. 4.38 [1.67–11.49]	1. 0.003 2. <0.001 3. 0.0027
Park et al, 2018[30]	1. Initial height loss; 2. Midportion type	Delayed neurological compromises	Multivariate logistic regression	1. 1.24 [1.04–1.46] 2. 14.90 [1.30–172.10]	1. 0.012 2. 0.030
Patil, S. and A.M. Nene 2014[31]	1. TL junction; 2. Superior endplate fracture	Segmental kyphotic deformity	Chi-square test	N/A	1. <0.002 2. <0.001
Smorgick et al, 2020[32]	Pelvic incidence, Pelvic tilt, Sacral slope	Height loss difference	Analysis of variance	N/A	>0.05
Sugita et al, 2005[33]	1. Swelled-front; 2. Bow-shaped; 3. Projecting	1. Vertebral collapse; 2. Vacuum cleft	Tukey multiple comparison test	N/A	<0.05
Suzuki et al, 2009[34]	Severely deformed fracture	1. Von Korff's pain intensity; 2. Von Korff's disability	Multiple linear regression	1. β=0.261 2. β=0.197	1. 0.007 2. 0.043
Toyoda et al, 2021[36]	1. Middle column injury; 2. TL junction	Delayed union	Multivariate logistic regression	1. 3.30 [2.08–5.23] 2. 2.53 [1.38–4.63]	1. 0.003 2. 0.001
Tsujio et al, 2011[38]	1. Middle column injury; 2. TL junction	Nonunion	Multivariate logistic regression	1. 3.5 [1.4–8.4] 2. 5.1 [1.4–18.1]	1. 0.006 2. 0.013
Takahashi et al, 2022[39]	Anterior height ratio	Nonunion	Multivariate logistic regression	0.979 [0.960–0.999]	0.042
Okuwaki et al, 2022[40]	VI	1. Collapse progression 2. KA progression	Multiple linear regression	1. β=0.286 2. β=0.468	1. 0.035 2. <0.001
Viswanathan et al, 2022[41]	1. Initial height loss; 2. Initial segmental Cobb angle	Vertebral collapse or pseudarthrosis	Multivariate logistic regression	1. 0.906 [0.829–0.989]; 2. 0.901 [0.770–1.055]	1. 0.028 2. 0.019
Chen SW et al, 2024[42]	TL junction (T10-L2)	1. ODI > 30 2. VAS > 6	Multiple logistic regression	1. 1.28 [1.18–1.39]; 2. 1.17 [1.10–1.23]	1. <0.001 2. <0.001
Ruiz Santiago F et al, 2023[43]	Difference PVH loss	Vertebral collapse	Multivariate logistic regression	1.306 [1.10–1.65]	0.003
Gutierrez et al, 2023[44]	1. A3 type 2. TL junction	Progression fracture	Multivariate logistic regression	1. 2.686 [1.649–4.374] 2. 1.712 [1.113–2.634]	1. <0.001 2. 0.014

Abbreviations: VI, vertebral instability; TL, thoracolumbar; HL, height loss; SF-36, Short Form-36; PCS, physical component summary; KA, kyphosis angle; N/A, not applicable; OR, odds ratio; β, standardized regression coefficients; ADL, Hannover activities of daily living score; ODI, Oswestry Disability Index; VAS, visual analog scale; PVH, posterior vertebral height.

5° on dynamic X-ray is a risk factor for delayed union, which further increases bed rest duration and risk of bed-related complications in elderly. Okuwaki, S. et al[40] similarly concluded that larger VI at the time of injury was significantly associated with a higher vertebral collapse rate after a 6-month follow-up. Unlike previous studies, they defined VI as the difference in height proportion between the anterior and posterior walls in the standing and supine positions.

Three articles[23,36,38] analyzed middle column injury as a risk factor. The middle column is composed of the posterior wall of the vertebral body, the posterior longitudinal ligament, and the posterior annulus fibrosus.[52] Hoshino, M. et al[23] conducted a prospective cohort study of 362 elderly patients and reported that these patients with middle–column injuries had lower SF-36 PCS scores, poorer daily activity function, longer pain duration and were more likely to experience vertebral body collapse during follow-up. Toyoda, H. et al[36] and Tsujio, T. et al[38] also reported that middle column injury is a risk factor for delayed vertebral union or nonunion in patients with OVCFs. In the study by Toyoda, H. et al[36] delayed union was defined as either the presence of a recognizable IVC on dynamic plain X-rays or apparent segmental

motion, which was defined as a change in the vertebral wedging angle over 5° between the supine and weight-bearing positions. In the study by Tsujio, T. et al,[38] nonunion was defined as the presence of a recognizable IVC on plain radiograph images.

Six articles[24,30,34,39,41,43] investigated the impact of initial fracture parameters, including vertebral height loss and the segmental kyphosis angle, on the prognosis of elderly patients receiving conservative treatment for OVCFs. Jeon et al[24] reported a positive correlation between initial vertebral collapse and the subsequent progression of vertebral collapse, which was defined as the percentage change in vertebral height loss between the initial stage of the fracture and 6 months after it occurred. The percentage of vertebral collapse was calculated via the following formula: [(upper vertebral height + lower vertebral height)/2 - affected vertebral height]/[upper vertebral height + lower vertebral height)/2]. Park et al[30] also calculated the degree of vertebral height loss and discovered that patients with a greater degree of vertebral body height loss had an increased risk of developing delayed neurological complications, such as radiculopathy and paraplegia, which were initially asymptomatic but subsequently developed during treatment. Takahashi et al[39] reported the vertebral anterior height ratio [2 × affected vertebral height/(lower vertebral height + upper vertebral height)] and reported that a decrease in the anterior height ratio was a predictor of nonunion. In a prospective cohort study, Viswanathan et al[41] demonstrated a statistical correlation between initial vertebral height loss, initial postinjury segmental Cobb angle, and poor prognosis of conservative treatment, including progressively greater vertebral collapse and pseudarthrosis. Pseudarthrosis was classified as the presence of a recognizable IVC at 3–6 months. Greater vertebral collapse was defined as one of two conditions: progressive loss of vertebral height ≥15% or total loss of vertebral height ≥50%. All four articles[24,30,39,41] mentioned above conducted an analysis of the initial vertebral segment angle. However, the study by Viswanathan, V. K. et al[41] was the only one that identified it as a risk factor. For initial vertebral height loss, while different definitions were used, all four articles[24,30,39,41] concluded that greater initial vertebral height loss was associated with a greater risk of poor prognosis after conservative treatment of OVCFs. In the study by Suzuki et al[34] a severely deformed fracture was characterized by a vertebral height or area loss of more than 40%. They reported that elderly patients with severely deformed fracture experienced more severe pain, disability in motor function, and reduced quality of life during 12 months of follow-up. By comparing the change in posterior vertebral height (PVH) on standing radiographs and prone CT images, Ruiz Santiago F et al[43] found that a change in the PVH of greater than 6% was a risk factor for high vertebral collapse, which was defined as a loss of greater than 50% of the vertebral body area or height at the final follow-up.

Six articles[27,31,36,38,42,44] examined the importance of thoracolumbar fracture segments as a risk factor for OVCFs in elderly patients. The thoracolumbar junction is defined as the region T10–L2 in the Chen SW et al[42] but was not defined in other studies. According to Toyoda et al[36] and Tsujio et al,[38] OVCFs are more likely to occur at the thoracolumbar level, and patients with thoracolumbar fractures are more likely to develop delayed nonunion. Muratore et al[27] reported that patients with thoracolumbar fractures presented greater vertebral collapse progression and higher pain scores. Similar results have also been reported by Gutierrez-Gonzalez R et al[44] and Chen SW et al.[42] Gutierrez-Gonzalez R et al reported that TL junction fracture is associated with the loss of vertebral height, and Chen SW et al reported that TL junction patients present with more severe pain (VAS score >6) and poorer quality of life (ODI score >30). Patil et al[31] reported that patients with a thoracolumbar junction fracture presented the highest risk for significant segmental kyphotic deformity, which was defined as a kyphotic angle over 30° by the Cobb method. In the same study, superior endplate fracture was also a risk factor for OVCFs.

Three articles[27,30,33] delineated the early morphology of OVCF fractures after their onset in elderly patients. Sugita et al[33] classified the early morphology of OVCFs into five categories on the basis of lateral radiographs of the anterior wall and endplate of the vertebral body: (a) swelled-front type, where more than half of the anterior wall of the vertebral body is swollen; (b) bow-shaped type, where the anterior wall is pinched in and the endplate is collapsing; (c) projecting type, where less than half of the anterior wall of the vertebral body is projecting; (d) concave type, where the anterior wall stays intact with the endplate collapsing only; and (e) dented type, where the anterior wall of the vertebral body is dented in the middle and a visible fracture line is present. The classification of morphology is presented in Figure 2. After performing a retrospective cohort analysis, Sugita et al[33] reported that patients with swelled-front type, bow-shaped type, and projecting type fractures had a significantly greater likelihood of

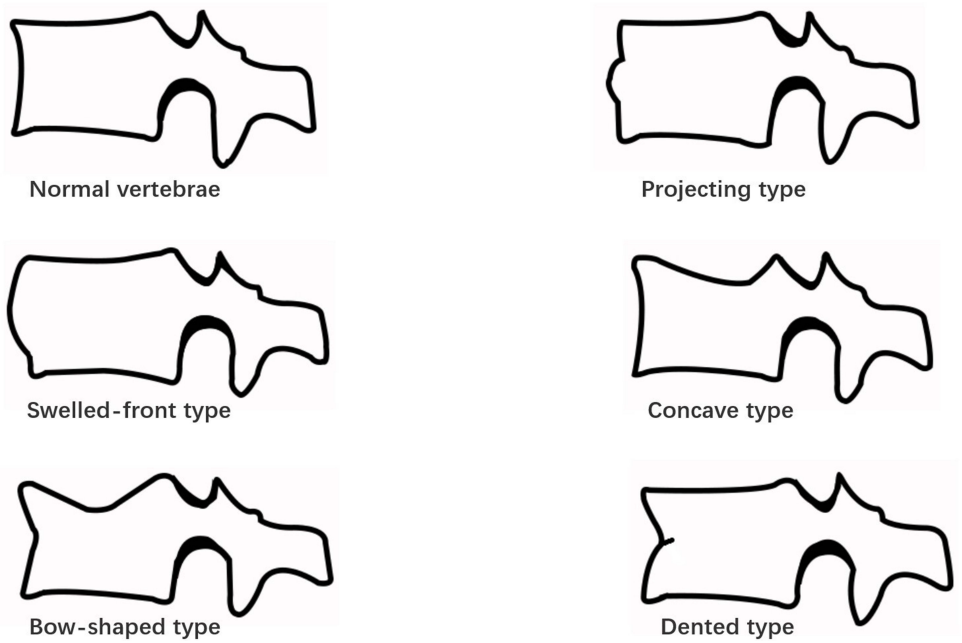

Figure 2 Sugita classification of the morphology of OVCF.

experiencing vertebral collapse and a vertebral vacuum cleft during conservative treatment in comparison to those with concave type and dented type fractures.

Muratore et al[27] and Park et al[30] utilized the same method to classify the early morphology of OVCFs. Muratore identified swelling and bow-shaped fractures as risk factors for vertebral collapse progression. Park combined swelled-front and dented types into the "midportion type", indicating vertebral injuries where the endplates remained intact and revealing a statistical correlation between the midportion type of fracture and delayed neurological complications. Although these three articles derived different types of poor prognoses due to distinct outcome indicators, the swelled-front type remained a high-risk fracture type in all of them. AO spine fracture classification was applied in the Gutierrez-Gonzalez et al study,[44] and the A3 type was found to be associated with fracture progression. A3 type fracture refers to an incomplete burst fracture in which only a single endplate and posterior wall are injured.[53]

Smorgick et al[32] included pelvic sagittal parameters, such as the pelvic incidence, pelvic tilt angle and sacral slope angle in their study but found no statistical correlation with vertebral collapse after conservative treatment of OVCFs.

MRI Findings

Risk factors were derived from MRI-related imaging methods in 13 articles. The detailed research results are presented in Table 4.

Six articles[21,22,36–38,41] analyzed the risk factors associated with certain T2-weighted imaging (T2WI) signal features, including confined high intensity features and diffuse low intensity features. Tsujio et al[38] conducted a prospective multicenter study with 350 OVCF patients from 25 institutes. After a 6-month follow-up period, the author's team discovered distinct characteristic signal intensities in nonunion patients. They were the first to categorize the vertebral intensity changes into five types on T2WI: confined high intensity, diffuse high intensity, confined low intensity, diffuse low intensity, and normal intensity. According to their study, confined high intensity and diffuse low intensity were found to be significant risk factors for nonunion. The specific image is shown in Figure 3. Ahmadi, S. A. et al.[22] Toyoda, H et al[36] and Takahashi, S et al[39] all demonstrated specific T2WI signal changes (confined high intensity and diffuse low intensity signals) during the acute phase as risk factors for nonunion or delayed union during conservative treatment of OVCF. It is worth noting that the authors of these four articles are all from the same Japanese research team, and their

Table 4 Risk Factors Based on MRI Findings

Author Year	Risk Factor (MRI Sequences)	Outcomes (Corresponding Risk Factors)	Statistical Test Methods	OR [95% CI] or β	P value
Abe et al, 2018[21]	Confined high intensity (T2WI)	Delayed union	Multivariate logistic regression	4.2 [2.0–8.8]	<0.001
Ahmadi et al, 2019[22]	Confined high intensity (T2WI)	Back pain	Multivariate logistic regression	3.96 [1.50–10.48]	<0.01
Jeon et al, 2021[24]	Fatty degeneration of the paraspinal muscle (T2WI)	Vertebral collapse	Multiple linear regression	β=0.724	<0.001
Lee et al, 2017[26]	Necrotic lesion area (CEMRI)	Further compression	Pearson method	N/A	<0.001
Muratore et al, 2020[27]	Linear black signal (STIR)	Vertebral collapse	Univariate logistic regression	5.73	0.0472
Omar et al, 2021[28]	SSIR (STIR)	Kyphosis angle	Multiple linear regression	N/A	0.017
Omi et al, 2014[29]	(1) Non-homogenous high signal (STIR); (2) Linear black signal (STIR)	Nonunion	Fisher's exact test	N/A	(1) 0.009 (2) 0.005
Toyoda et al, 2021[36]	Confined high and diffuse low intensity (T2WI)	Delayed union	Multivariate logistic regression	5.789 [3.591–9.331]	<0.001
Tsujio et al, 2011[38]	(1) Confined high intensity (2) Diffuse low intensity (T2WI)	Nonunion	Multivariate logistic regression	(1) 32.3 [11.0–94.9] (2) 6.8 [2.5–18.3]	(1) <0.001 (2) <0.001
Takahashi et al, 2022[39]	High intensity and diffuse low intensity (T2WI)	Nonunion	Multivariate logistic regression	7.638 [4.145–14.073]	<0.001
Viswanathan et al, 2022[41]	(1) PLC injury (STIR); (2) Confined high and diffuse low intensity (T2WI)	Vertebral collapse or pseudarthrosis	Multivariate logistic regression	(1) 42.279 [1.045–1710.880] (2) 0.023 [0.001–0.800]	0.047 0.037
Ogon I et al, 2023[45]	D*(IVIM)	Nonunion or high-collapse	Analysis of variance	N/A	<0.05
Wakao N et al, 2023[46]	Presence of posterior wall injury	Pseudoarthrosis	Multivariate logistic analyses	2.059 [1.037–4.088]	0.039

Abbreviations: MRI, magnetic resonance imaging; T2WI, T2 weighted imaging; CEMRI, contrast-enhanced magnetic resonance image; STIR, short-tau inversion recovery; SSIR, spinal signal intensity ratio; PLC, posterior ligamentous complex; OR, odds ratio; β, standardized regression coefficient; N/A, not applicable; D*, perfusion-related diffusion; IVIM, intravoxel incoherent motion.

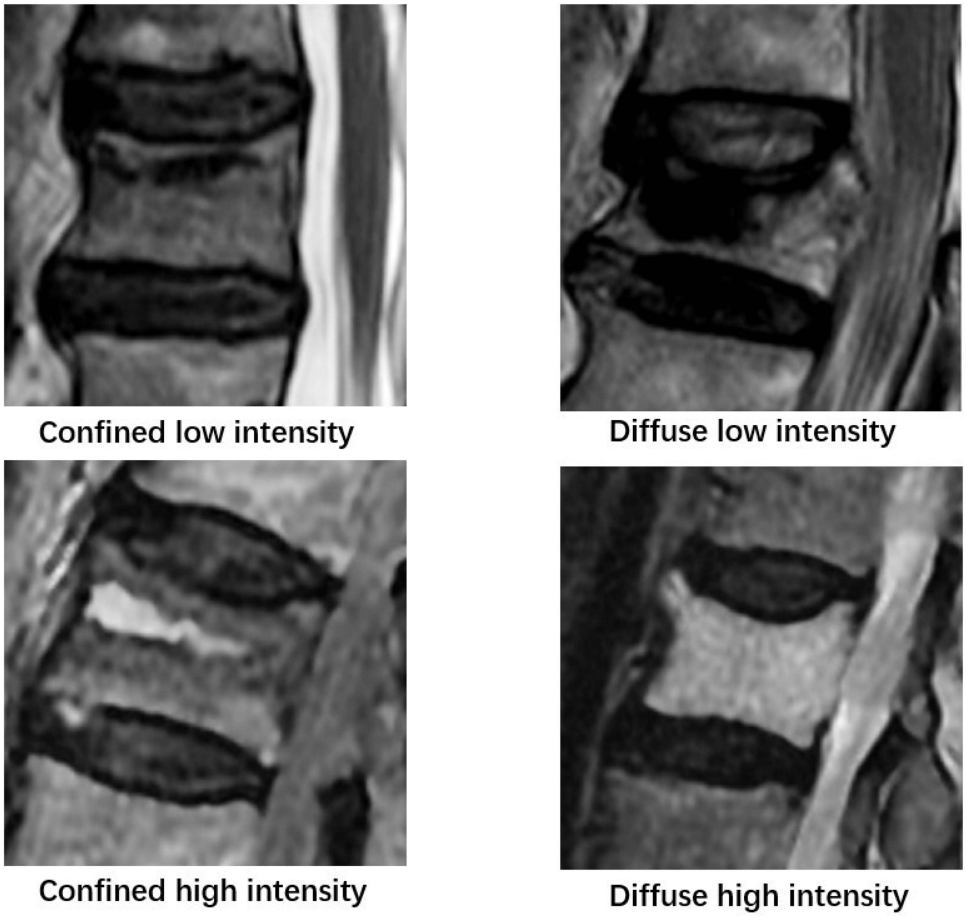

Figure 3 Tsujio's classification of signal intensity in fractured vertebrae on T2WI.

data may overlap with each other. Among them, Toyoda, H et al[36] conducted the largest prospective cohort study, evaluating a total of 508 patients with OVCFs from 25 institutes. The authors identified three independent risk factors for delayed union of OVCFs: thoracolumbar vertebral involvement, middle column injury, and specific T2WI signal changes. When a patient has multiple risk factors, the probability of delayed union occurring during conservative treatment increases-a cumulative risk with severe implications for elderly patients' quality of life. Additionally, Abe, T. et al[21] and Viswanathan, V. K. et al[41] from other research teams, both reported that confined high intensity or diffuse low intensity signals on T2WI are independent risk factors for delayed union or pseudarthrosis.

MRI was also used to identify injuries of posterior ligamentous complex (PLC) in Viswanathan, V. K. et al[41] and injuries of the posterior wall (essentially a type of middle column injury) in Wakao N et al.[46] Both injuries are highly correlated with pseudoarthrosis.

Three articles[27–29] investigated the characteristic signals on short-tau inversion recovery (STIR) MRI. Omi, H. et al[29] classified OVCF patients on the basis of the homogeneity of the signal or the presence of black line signals on STIR MRI. They reported that non-homogenous high signal change cases were prone to nonunion and that vertebral collapse quickly progressed. In addition, patients with linear black signals experienced more significant pain during follow-up. Muratore, M. et al[27] also reported that the linear black areas on STIR MRI were negative prognostic factors for vertebral collapse during conservative treatment. The specific signal intensity changes on the STIR MRI are shown in Figure 4. According to the work of Luoma, E.K. et al[54] and Smith, S. A. et al[55] the signal intensity of cerebrospinal fluid (CSF) remains constant, regardless of its chemical composition. On the basis of these findings, Omar Pacha, T et al[28] calculated the spinal signal intensity ratio (SSIR) by dividing the edema intensity in the fractured vertebra by the intensity of the CSF to determine the degree of vertebral bone edema. After a 6-month follow-up period, they reported a positive

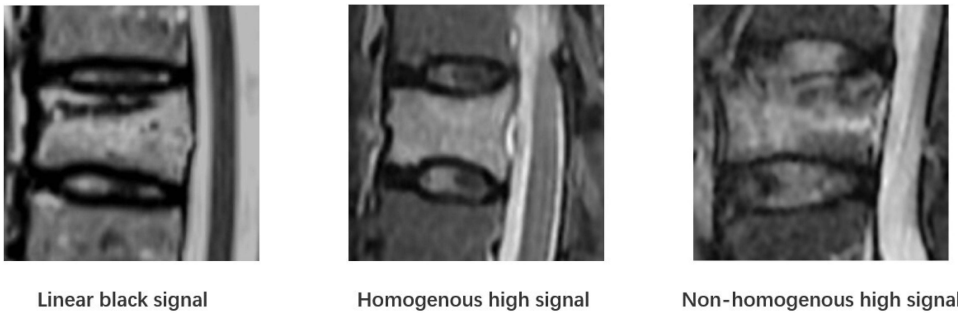

Figure 4 Specific signal intensity characteristics on STIR MRI.

correlation between the SSIR on the STIR and kyphosis, indicating that the degree of vertebral bone edema affects the prognosis of OVCFs. However, this result was not significant in the T1- or T2-weighted images.

Lee, J.M., et al[26] described the vertebral necrotic area as the region of the image that remained unenhanced on contrast-enhanced magnetic resonance imaging (CEMRI), which consists of a set of sequentially acquired images produced during the passage of a contrast agent. The necrotic area detected by CEMRI in OVCF patients was strongly associated with further vertebral compression. In Ogon I et al's study,[45] patients were subjected to intravoxel incoherent motion (IVIM) examination, which is a diffusion-weighted imaging (DWI) technique in MRI. Among these IVIM parameters, the D* parameter is thought to be associated with high vertebral collapse and nonunion.

Jeon et al[24] calculated the ratio of the functional cross-sectional area (CSA) to the total CSA of the paraspinal muscle in order to reflect the degree of muscle fat degeneration. The functional CSA represents the fat-free, lean paraspinal muscle that can be measured via a threshold grayscale.[56] In this study, the authors reported that individuals with a lower functional CSA ratio (more common in the elderly population and is known as sarcopenia) presented more severe progression of vertebral collapse.

Ruiz Santiago et al[43] compared the HU values of fractured versus non-fractured vertebrae on CT and reported that a density ratio ≥ 2 is a risk factor for collapse.

Discussion

In recent years, there has been a significant increase in the incidence of OVCFs in China, predominantly affecting adults aged 65 years and older, with an estimated three million cases expected by 2050.[57] The American Academy of Orthopedic Surgeons (AAOS) recommends conservative treatment, including bed rest, analgesics, brace support, early rehabilitation, and anti-osteoporosis treatment, for managing symptomatic OVCFs.[58] Although most patients benefit from conservative treatment and have a good prognosis, 13.5%-35% of patients may still develop complications, such as nonunion, collapse progression, kyphosis deformity, and back pain.[4,38,58,59] Nonunion or delayed union of fractures is the most significant complication of conservative OVCF treatment, which may cause residual low back pain, poor quality of life, musculoskeletal disorders, and even deterioration of cognitive status- a cascade of decline amplified in geriatric populations with preexisting frailty.[60,61] Nonunion is also closely associated with vertebral collapse progression.[8] Kummell's disease due to postfracture ischemic necrosis, which usually manifests on images as IVCs, is a common mechanism of vertebral progressive collapse and nonunion.[62] Progressive vertebral collapse can result in a loss of vertebral height and kyphosis deformity, which have a severe negative impact on elderly patients' quality of life and may increase mortality.[5,6] Since these complications are interrelated, we refer to them collectively as poor prognosis. We conducted a search and screening process, ultimately retained 26 articles and summarized the risk factors (nonimaging, X-ray, and MRI findings) related to the poor prognosis for patients receiving conservative treatment of OVCFs. It should be noted that most of the included studies were conducted in Japan and Korea, with limited evidence from other regions. Such regional concentration may influence the generalizability of our findings, as osteoporosis management practices and patient characteristics can differ among populations.

Age, as a main independent predictive factor of osteoporosis,[63] was the most commonly analyzed nonimaging factor. Although four studies[23,39,43,46] have shown that advanced age is associated with poor prognosis, a problem is the lack of a definite cutoff value for age as a risk factor. And it is worth noting that age was not correlated with prognosis in other studies. This variation may stem from that age-related confounding factors (eg, comorbidities like diabetes, cognitive impairment, or psychological disorders) were not controlled in most analyses; these factors often coexist with advanced age and affect fracture healing, thereby masking or exaggerating the direct impact of age on prognosis.[64] Similarly, almost all of the articles included gender in their studies, but only two reported positive results and completely opposite conclusions.[23,44] This discrepancy is closely tied to OVCF inherent epidemiological bias (female majority) and flaws in study design. Many studies lacked strict sex-specific inclusion rules or stratified analyses, causing insufficient statistical power to detect true sex-prognosis links. This inconsistency highlights the need for large-scale, prospective, and multicenter studies to clarify the role of demographic factors in OVCF prognosis. Another major nonimaging risk factor is previous spine fracture, a mark of fragility in elderly individuals that initiates a vicious cycle of functional decline. Physical inactivity and restricted movement caused by a previous fracture are likely to accelerate bone mineral loss and aggravate bone fragility, exacerbating sarcopenia—a common condition in older adults that further impairs mobility and recovery.[35] Moreover, preexisting vertebral fractures cause depression and panic about falls in elderly patients, which negatively impacts the prognosis of conservative treatment.[65] Tomoyuki Kusukawa et al[66] confirmed that recurrent OVCFs in the short term have a negative effect on QOL, with elderly patients showing slower recovery of activities of daily living after repeated fractures compared to younger cohorts. Patients with previous fractures usually have poorer quality of life than those without previous fractures, making it difficult to balance the baseline levels of functional impairment and creating resistance to further research. The level of 25(OH)D is another risk factor for osteoporosis,[40] usually due to reduced sun exposure, malabsorption, and impaired vitamin D metabolism in elderly populations. The T-score is an indicator of the severity of osteoporosis, and Takahashi et al[39] reported a correlation between the T-score and nonunion. Both findings suggest the impact of the severity of osteoporosis on the poor prognosis of conservatively treated OVCFs. However, in some other studies,[30,40] there was no statistical association between BMD values and delayed neurologic compromises, vertebral collapse, or kyphotic progression. This suggests that the impact of low bone mineral density on the prognosis of conservative treatment for OVCF may be indirect, such as increased bone fragility that elevates fracture severity and thereby affects prognosis. Additionally, population differences and inconsistencies in conservative treatment approaches—including whether anti-osteoporotic treatment is administered and the specific treatment regimens—may also contribute to the variations observed across these studies. Fernando Ruiz Santiago et al[43] further compared the HU values of fractured versus nonfractured vertebrae and reported that a ratio greater than 2 is a risk factor for vertebral collapse. The authors concluded that a larger HU value in fractured vertebrae is suggestive of sclerosis of the trabecular bone within the vertebral body, a sign that manifests as a low-signal region on MRI T2WI, which is consistent with previous studies.[36,38,39]

X-rays are the most commonly used clinical method for diagnosing spine fractures because they provide a clear view of the fracture segment and its morphology,[67] with particular utility in geriatric populations due to their accessibility and suitability. Dynamic X-rays can also be used to estimate the stability of fractured vertebrae by calculating the difference in the segmental angle. The TL junction is considered a stress concentration area of the spine because of the gradual transition from thoracic kyphosis to lumbar lordosis.[68] Most OVCFs occur in elderly individuals.[3] Considering that degenerative factors such as reduced disc height and increased thoracic lordosis result in a forward shift in the body's center of gravity, the compressive force on the TL junction area is much greater.[27] This explains why the TL junction segment is the most common site of vertebral fractures and why elderly OVCF patients with TL junction involvement are prone to a poor prognosis. The middle column is the main load-bearing part of the spine column according to the Denis three-column theory, and it plays a crucial role in spinal stability.[52] Middle column injury involving the posterior wall or posterior longitudinal ligament of the vertebral body can result in bone and nucleus pulposus tissue fragments protruding into the spinal canal, compressing the spinal cord or the cauda equina. Gutierrez-Gonzalez R et al[44] proposed the A3 type as a risk factor, and one of the characteristics of this type of fracture is injury to the posterior wall (middle column) of the vertebral body. Wakao N SA et al[46] identified posterior wall injury by signal changes on MRI and confirmed it as a risk factor for pseudoarthrosis. In a study by Ruiz Santiago F et al[43] differences in PVH loss were considered risk factors for

collapse. Changes in the PVH between the standing and supine positions suggest both middle column injury and vertebral instability. All these studies suggest a strong correlation between mid-column injury, vertebral instability and poor prognosis in patients with OVCFs. Clinically, we commonly find OVCF morphology as either a wedge, compression, or biconcavity, however, these patterns typically arise from progressive vertebral collapse and only become evident in the middle to late stages of the fracture. Sugita, M et al[33] found that the morphology of OVCFs in the early acute phase is typically swelled or dented rather than collapsed. According to Sugita, M's classification, vertebrae with simple anterior wall injuries exhibit a pattern of anterior wall depression, and the prognosis generally improves because only the anterior column is involved. The anterior wall protruding pattern is considered to be the result of simultaneous anterior wall injury and middle column disruption. The more protrude it is, the more serious the anterior wall and middle column injury, leading to the worst prognosis in the swelled-front type. The initial vertebral fracture parameters directly reflect the severity of the fracture. Greater kyphosis and height loss in the fractured vertebra indicate more severe vertebral injury and a greater risk of a poor prognosis.[34] Notably, Study by Park et al[30] is the only one that incorporates neurological comorbidities as an outcome measure, and found two risk factors: the midportion type (swelled-front and dented type in the Sugita classification) and initial height loss. Given that neurological impairment exerts a substantially greater impact on patients' quality of life relative to other outcomes (eg, vertebral collapse, kyphotic progression), these two parameters warrant heightened attention in clinical assessment and subsequent research. Vertebral instability indicates the loss of continuity of the trabecular structure of the fractured portion of the vertebrae, which might have a negative impact on bone union.[21] Nonunion, IVC, and vertebral instability interact with each other. Nonunion is a clinical outcome that requires long-term follow-up. IVC usually appears approximately three weeks after injury,[69] whereas only vertebral instability can be measured at the beginning of the fracture.[21,40] In older adults whose bone healing is delayed, the greater the instability of the fractured vertebra is, the greater the likelihood that an IVC will occur, and the greater the probability of nonunion. Vertebral instability is also directly related to clinical symptoms, such as delayed nerve injury.[70] The IVC extends anteriorly, with mild external forces repeatedly loaded on the fissure, followed by stress concentration on the posterior superior wall of the vertebral body, leading to injury of the anterior wall of the vertebral body, collapse of the posterior margin, and entire vertebrae destruction.[71]

MRI provides valuable information for the diagnosis and prognosis of OVCF patients. Qasem, K. M. et al[72] suggested that using MRI combined with lateral X-ray can identify acute or old osteoporotic vertebral fractures, a distinction critical for elderly patients with a high prevalence of pre-existing spinal degenerative changes. Additionally, MRI can differentiate between benign and malignant vertebral collapse[73] and can provide more accurate identification in cases of osteoporotic and infected fractures.[74] As a noninvasive imaging technique, MRI is a recommended diagnostic and follow-up tool for OVCF patients. The risk factors observed on MRI in this review focus mainly on T2WI and STIR sequences. In 2011, a classification method based on signal intensity and whether it is confined on MRI T2WI was proposed by Tsujio, T. et al for the first time.[38] The author noted that the confined high intensity on T2WI may be related to repetitive mechanical compression at the fracture site, whereas diffuse low intensity reflects extensive vertebral injury fibrosis. Both factors are associated with vertebral instability and result in nonunion. STIR is the earliest and most widely used fat suppression technique in MRI sequences, with higher sensitivity in the diagnosis of OVCFs.[75] Omi, H. et al[29] reported that homogenously high signal changes in the STIR sequence indicate bone marrow edema after mild trabecular injury, whereas a linear black signal pattern indicates compressed cancellous bone after severe trabecular injury, which increases instability, eventually leading to collapse. Qi, H. et al[76] also reported that areas with low signals on T1WI and high signals on T2WI commonly indicate bone marrow edema and are positively correlated with low back pain, a major contributor to functional decline in older adults. The severity of fracture can be determined by the signal intensity of bone marrow edema on T2WI and STIR sequences. However, the use of the SSIR as a risk factor for conservative treatment for OVCFs is valid only on STIR images and not on T2WI.[28] CEMRI can be used to verify the range of avascular necrosis precisely.[77] The nonenhanced area observed on CEMRI is an indicator of vascular injury and inadequate revascularization, which hinder the fracture healing process, ultimately leading to vertebral collapse. On this basis, it can be used to predict the pattern and quantity of bone cement injection during percutaneous vertebroplasty.[78] In the study of Ogon I et al[45] a decrease in the D* parameter of IVIM was also considered to suggest that vertebral blood perfusion was disrupted, resulting in collapse and nonhealing, which amplified in the elderly population with comorbid vascular

diseases. All indications suggest that impaired perfusion is an important cause of poor prognosis in OVCFs, and how to assess vertebral perfusion efficiently and accurately will be the focus of further research. The paraspinal muscles play a significant role in vertebral stability and functional movement.[79] When OVCF occurs, the paraspinal muscles form a tension band posteriorly, reducing excessive flexion and loading on the vertebral body. However, fatty degeneration of these muscles reduces their tension, causing excessive kyphosis and center of gravity anteversion, ultimately resulting in increased vertebral compression and collapse.[24] A balance between bony stability and soft tissue support is essential for spinal function.[80] Research on paraspinal muscles has opened new areas for investigating the impact of soft tissue on OVCFs, particularly in elderly patients where sarcopenia accelerates functional deterioration. The exercise of paraspinal muscles may also help improve the prognosis of elderly OVCF patients.

Conservative treatment modalities have an impact on the prognosis of OVCFs.[81,82] However, these factors were not further analyzed in this review because conservative treatment modalities vary widely among articles or fail to be specifically described. This review focused on the prognostic factors that can be obtained at the early stages of fracture diagnosis, a critical window for guiding interventions in elderly patients to prevent functional decline.

In 2017, Muratore, M. et al[15] identified major complications (vertebral collapse, kyphosis, pseudoarthrosis, and neurologic deficit) as outcomes and reviewed predictors of conservative treatment failure for OVCFs, ultimately including 11 articles. In 2022, Max J Scheyerer et al[16] conducted a systematic review and summarized the risk factors for the failure of conservative treatment for OVCFs. The authors only searched the literature prior to 2016 and 2020 respectively, and the inclusion of adverse prognoses was not comprehensive. In addition, the Max J Scheye et al review[16] did not strictly limit the time of acquisition of clinical data used to predict prognosis or the duration of follow-up, leading to some of the included articles with risk factors being associated with poor prognosis only as a cross-sectional correlation, not as a predictive effect.

In our systematic review, we summarized the most recent literature up to June 2025 and included 26 articles, focusing not only on specific clinical complications but also on pain symptoms, functional impairment, and quality of life scores. Risk factors had to be identified at initial diagnosis, and the follow-up process was strictly limited to at least 3 months to ensure that the included risk factors were all predictors of poor distant prognosis. Therefore, research from Lee HM et al[14] and Zhang J et al.[83] Despite similar findings from cohort studies, these studies were not included in our review because they did not meet the inclusion criteria due to a follow-up period of only 3 weeks. Our review aims to help clinicians judge the prognosis of conservative treatment at the initial diagnosis of new-onset OVCF. The clinical examination methods were used as classification criteria to better meet clinical needs.

Currently, a significant challenge with the available studies is that they merely describe which factors contribute to poor prognosis in OVCF conservative treatment and the strength of their correlation, but there is no integration of risk factors or accurate prediction of the probability. However, in 2022 and 2023, research teams from Japan[39] and Korea,[84] respectively, attempted to use machine learning algorithms to integrate risk factors such as demographic data, fracture type, and MRI findings to predict the outcome of conservative treatment for OVCFs. They discovered that machine learning algorithms provided higher accuracy and specificity than logistic regression and decision tree models did. Although the predictive model used is not yet publicly available, it offers new research directions for future model prediction. To translate such models into practice, two core steps matter: First, multi-center external validation is critical. Validating models trained on East Asian cohorts with data from other regions can test generalizability, addressing geographical limitations. Second, for daily clinical application, the model can optimize initial risk stratification: at acute OVCF diagnosis, clinicians input accessible variables (demographic data, imaging findings) into a simple tool to get personalized poor-prognosis scores. High-risk patients get priority for surgical consultation; low-risk patients follow standard conservative treatment. The results of this review provide more complete evidence to support clinical model parameter selection, and it is hopeful that future studies could provide more effective methods for predicting the clinical outcomes in OVCF patients receiving conservative treatment to better guide the selection of clinical treatment tailored to elderly individuals' functional reserve and care goals.

Limitations

Among the 26 included articles, fewer than half were prospective studies, and the majority were retrospective observational cohort studies. The heterogeneity of the articles included in this review makes it challenging to standardize the inclusion or exclusion criteria, follow-up duration and definition of poor prognosis across articles. In particular, conservative treatment regimens vary significantly across different studies, leading to discrepancies in research findings and limits the comparability between studies. Individual differences (such as treatment engagement and medication adherence) were not analyzed in this review, due to the lack of reporting on these factors in the included studies. Confounding factors also vary between articles, and although NOS scores were used to minimize bias, different statistical tests and diverse included parameters are not suitable for further meta-analysis. Since most studies were from East Asia, there is a risk of publication bias. Negative or neutral findings from other regions may not be included, and this could limit the overall balance of the evidence. Additionally, only positive results were reported, potentially leaving out some conflicting or meaningful negative results.

Conclusion

This systematic review identified risk factors associated with conservative treatment of OVCFs in elderly populations. The major nonimaging risk factors include age and previous spine fracture. X-ray and MRI are useful diagnostic tools for OVCFs and provide predictive information. Vertebral instability, middle column injury, initial vertebral parameters, TL junction fracture, and specific fracture patterns (swelled-front type or A3 type) are major risk factors visible on X-ray. On MRI, specific feature signals (confined high intensity and diffuse low intensity) on T2WI and non-homogenous high signals with a linear black area on STIR are valuable risk factors, in addition to nonenhanced areas on CEMRI, the D* parameter on IVIM and fatty degeneration of the paravertebral muscle. Identifying these risk factors early can help in making appropriate treatment decisions for OVCF patients.

Abbreviations

OVCF Osteoporotic Vertebral compression fracture; BMD Bone mineral density; MeSH Medical Subject Heading; PRISMA Preferred Reporting Items for Systematic Reviews and Meta-Analyses; NOS Newcastle–Ottawa Scale; IVC intravertebral cleft; CEMRI contrast-enhanced magnetic resonance image; STIR short-tau inversion recovery; CSA cross-sectional area; 25(OH)D 25-hydroxy vitamin D; MRI magnetic resonance image; T1WI T1 weighted imaging; T2WI T2 weighted imaging; SF-36 Short Form-36; PCS physical component summary; MCS mental component summary; ODI Oswestry Disability Index; ADL activities of daily living; EQ-5D EuroQol five dimensions questionnaire; VAS visual analog scale; ANOVA analysis of variance; OR odds ratio; β Standardized regression coefficients; N/A not applicable; NR not reported; CT computed tomography; VI vertebral instability; SSIR spinal signal intensity ratio; TL thoracolumbar; PLC Posterior ligamentous complex; QoL quality of life; CSF cerebrospinal fluid; CSA cross-sectional area; PVH posterior vertebral height; IVIM Intravoxel incoherent motion.

Ethics Approval and Informed Consent

This systematic review is based on previously published studies and does not involve human subjects, animal experiments, or the collection of original data. Therefore, ethical approval and informed consent are not required.

Consent for Publication

Written consent for publication was obtained from the patient for the inclusion of identifying information (including clinical photographs) in this manuscript.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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