www.directivepublications.org

The Journal of Orthopaedics

ISSN 2996-1777

Review Article

Management of Complications Following Fragility Fractures in Postmenopausal Women: Current Evidence and Future Directions: Meta-Analyses.

Osman Suliman[1], Sara Altom[2], Maan Almehmadi[3], Abdullah Alamri[3], Zainab Abdullah[3], Rana Abdelmagid[4], Riham Abdelmagid[4], Ahmed Abdelmagid[5].

1.Department of Surgery, Faculty of Medicine, University of Medical sciences and Technology (UMST) Khartoum, Sudan.

2.Department of Basic Sciences, Al-Rayan National College of Medicine, Al- Rayan National Colleges, Al-Madinah, Saudi Arabia.

3.Al-Rayan National College of Medicine, Al-Rayan National Colleges, Al-Madinah, Saudi Arabia.

4.Faculty of Medicine, Capital University, Cairo, Egypt.

5.Emergency Department, St. George's Hospital Foundation Trust. London, United Kingdom.

Abstract

Background: Fragility fractures in postmenopausal women represent a major global health concern due to age-related osteoporosis and estrogen deficiency. These fractures are frequently associated with significant complications such as delayed union, nonunion, infection, fixation failure, refracture, and functional decline, leading to increased morbidity, mortality, and healthcare burden.

Objective: To systematically evaluate and synthesize current evidence on the management of complications following fragility fractures in postmenopausal women and to identify effective therapeutic, surgical, and rehabilitative strategies for improving clinical outcomes.

Methods: A systematic review and meta-analysis were conducted in accordance with PRISMA guidelines. A comprehensive search of PubMed, Scopus, Web of Science, Embase, and Google Scholar was performed for studies published between January 2022 and March 2026. Studies involving postmenopausal women with fragility fractures and reporting management of related complications were included. Data were extracted and analyzed using qualitative synthesis and, where appropriate, quantitative methods.

Results: A total of 30 studies met the inclusion criteria. The most common complications identified were nonunion, delayed union, infection, fixation failure, refracture, and functional impairment. Pharmacological therapies, particularly anabolic and antiresorptive agents, demonstrated benefits in improving bone healing and reducing fracture risk. Early surgical intervention was associated with better outcomes, while rehabilitation programs improved functional recovery and reduced frailty. Fracture liaison services significantly reduced secondary fractures and improved treatment adherence.

Conclusion: Management of fragility fracture complications in postmenopausal women requires a multidisciplinary approach combining pharmacological treatment, surgical optimization, rehabilitation, and preventive healthcare strategies. Despite advances, gaps remain in standardized care and high-quality evidence, highlighting the need for further research and integrated clinical pathways.

Keywords: Fragility fractures; Postmenopausal women; Osteoporosis; Fracture complications; Nonunion.

***Corresponding Author:** Dr. Osman Suliman. Department of Surgery, Faculty of Medicine, University of Medical sciences and Technology (UMST) Khartoum, Sudan. **Email:** drosy442@gmail.com.

Received: 11-May-2026, Manuscript No. TJOP - 5754 **; Editor Assigned:** 12-May-2026 **; Reviewed:** 02-June-2026, QC No. TJOP - 5754 **; Published:** 09-June-2026. **DOI:** 10.52338/tjop.2026.5754.

Citation: Dr. Osman Suliman. Management Of Complications Following Fragility Fractures In Postmenopausal Women: Current Evidence And Future Directions: Meta-Analyses. The Journal of Orthopaedics. 2026 June; 17(1). doi: 10.52338/tjop.2026.5754.

Copyright © 2026 **Dr. Osman Suliman.** This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

INTRODUCTION

Fragility fractures represent a major and growing public health concern worldwide, particularly among postmenopausal women, in whom the decline in estrogen levels significantly accelerates bone loss and compromises skeletal integrity. Osteoporosis, the underlying condition responsible for most fragility fractures, is characterized by reduced bone mineral density and deterioration of bone microarchitecture, predisposing individuals to fractures even after minimal trauma. Among postmenopausal women, common fracture sites include the hip, vertebrae, pelvis, and long bones, all of which are associated with substantial morbidity, reduced quality of life, and increased mortality. As global life expectancy continues to rise, the burden of osteoporotic fractures and their associated complications is expected to increase dramatically, placing additional strain on healthcare systems. [1] While the initial management of fragility fractures has been extensively studied, increasing attention is being directed toward the complications that arise during the healing process and recovery period. These complications include delayed union, nonunion, infection, fixation failure, refracture, chronic pain, and functional decline. Such adverse outcomes not only prolong hospitalization and rehabilitation but also significantly impact long-term independence and survival, particularly in elderly populations. Hip fractures, for instance, are associated with a one-year mortality rate of up to 20–30%, emphasizing the critical need for effective management strategies that extend beyond the acute phase of care. [2]

The pathophysiology of fracture complications in postmenopausal women is multifactorial. Estrogen deficiency leads to increased bone resorption and impaired bone formation, resulting in delayed healing and reduced biomechanical strength at fracture sites. [3] Additionally, age-related comorbidities, including diabetes, cardiovascular disease, and sarcopenia, further complicate recovery and increase the risk of adverse outcomes. [4] Nutritional deficiencies, particularly in calcium and vitamin D, along with reduced physical activity, also contribute to poor fracture healing and increased susceptibility to subsequent fractures. [5] Management of complications following fragility fractures requires a comprehensive and multidisciplinary approach. Pharmacological interventions play a central role, with antiresorptive agents such as bisphosphonates and denosumab, as well as anabolic agents like teriparatide, demonstrating efficacy in improving bone density and reducing fracture risk. [6] Hormone replacement therapy has also been shown to have beneficial effects in selected populations. In addition to pharmacotherapy, surgical management—including optimal timing of intervention and advanced fixation techniques—remains critical in minimizing complications such as implant failure and nonunion. [7]

Rehabilitation strategies are equally important in improving functional outcomes and reducing the risk of long-term disability. Early mobilization, physiotherapy, and structured exercise programs have been shown to enhance recovery, improve muscle strength, and decrease the incidence of frailty and falls. [8] Furthermore, healthcare system interventions such as fracture liaison services have emerged as effective models for coordinating post-fracture care, ensuring appropriate evaluation, treatment, and follow-up to prevent secondary fractures.

Despite advances in the management of fragility fractures, significant gaps remain in the understanding and prevention of associated complications. Variability in clinical practice, limited adherence to treatment guidelines, and disparities in access to care continue to hinder optimal outcomes. Moreover, emerging therapies, including biologic agents and regenerative approaches, offer promising avenues but require further investigation through high-quality studies. [9] Given these challenges, there is a critical need to synthesize current evidence on the management of fracture-related complications in postmenopausal women. This study aims to systematically review and analyze recent literature to evaluate existing management strategies, identify key determinants of outcomes, and highlight future directions for research and clinical practice. By providing a comprehensive overview of current evidence, this work seeks to inform clinicians, researchers, and policymakers in developing effective interventions to reduce the burden of fragility fracture complications in this vulnerable population. [10] [11]

OBJECTIVES OF THE STUDY

The primary objective of this study was to systematically evaluate and synthesize current evidence on the management of complications following fragility fractures in postmenopausal women, with the aim of improving clinical outcomes and informing future research directions. Specifically, the study sought to identify the most common complications associated with fragility fractures in this population and to assess the effectiveness of various management strategies. These included pharmacological interventions such as antiresorptive and anabolic therapies, as well as surgical approaches focusing on timing and fixation techniques to reduce complication rates. Additionally, the study aimed to analyze the role of rehabilitation and structured exercise programs in enhancing functional recovery and preventing long-term disability. The effectiveness of healthcare system interventions, including fracture liaison services and preventive screening programs, was also examined in relation to reducing secondary fractures. Furthermore, the study explored key risk factors associated with poor healing outcomes, including nonunion and infection, and aimed to highlight existing gaps in the literature while proposing directions for future research and clinical practice.

METHODOLOGY

This study was conducted as a systematic review and meta-analysis in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency, reproducibility, and methodological rigor in the identification, selection, and analysis of relevant studies. The literature search encompassed studies published between January 2022 and March 2026, thereby capturing the most recent and clinically relevant evidence on the management of complications following fragility fractures in postmenopausal women.

Eligibility criteria were clearly defined prior to study selection. Studies were included if they involved postmenopausal women with fragility fractures and addressed complications such as nonunion, delayed union, infection, fixation failure, refracture, or mortality. Additionally, only studies evaluating management strategies—including pharmacological interventions, surgical approaches, rehabilitation programs, or healthcare system-based interventions—were considered. Eligible study designs included systematic reviews, meta-analyses, randomized controlled trials, cohort studies, and case–control studies, provided they were published in English within the specified time frame.

Studies were excluded if they involved non-human subjects, were not specific to postmenopausal women, or did not report relevant outcomes related to fracture complications. Furthermore, case reports, editorials, and narrative reviews lacking sufficient clinical data were excluded, as were duplicate publications and studies with incomplete or insufficient data. This rigorous selection process ensured that only high- quality and relevant evidence was included in the analysis.

Methods of Data Collection

A comprehensive search strategy was applied across multiple databases, including PubMed, Scopus, Web of Science, Embase, and Google Scholar. Relevant keywords and Medical Subject Headings (MeSH) terms were used, such as “fragility fractures,” “postmenopausal women,” “osteoporosis,” “fracture complications,” “nonunion,” “infection,” and “fracture management.” Two independent reviewers screened titles and abstracts for eligibility, followed by full-text assessment. Discrepancies were resolved through discussion or consultation with a third reviewer. Data extraction was performed using a standardized form, capturing study characteristics, population details, interventions, outcomes, and key findings.

Analysis of Data

Data were analyzed using both qualitative and quantitative approaches. A descriptive synthesis was performed to summarize study characteristics, types of complications, and management strategies. For studies with comparable outcomes, a meta-analysis was conducted using appropriate statistical models. Effect sizes such as risk ratios (RR), odds ratios (OR), and hazard ratios (HR) with 95% confidence intervals (CI) were calculated. Heterogeneity among studies was assessed using the I^2 statistic, with values above 50% indicating substantial heterogeneity. Where appropriate, subgroup analyses were performed based on type of intervention, fracture site, and study design. Publication bias was evaluated using funnel plots and statistical tests. Statistical analysis was conducted using standard software such as RevMan or STATA, ensuring robustness and reliability of findings.

Literature Review

Fragility fractures are a hallmark complication of osteoporosis and represent a major health burden among postmenopausal women worldwide. The decline in estrogen levels following menopause leads to accelerated bone resorption, reduced bone mineral density, and increased susceptibility to fractures even with minimal trauma. Hip, vertebral, and wrist fractures are among the most commonly reported, each associated with significant morbidity, mortality, and healthcare costs. [12]

A growing body of literature has emphasized that the burden of fragility fractures extends beyond the initial injury, with complications during healing and recovery contributing substantially to adverse outcomes. Delayed union and nonunion are among the most frequently reported complications, particularly in osteoporotic bone where impaired remodeling and reduced vascularity hinder normal healing processes. [13] [14]

Infection and sepsis following fractures, especially in surgically managed cases, represent another critical concern. Evidence suggests that elderly patients with fragility fractures are more vulnerable to postoperative infections due to weakened immune responses and prolonged hospital stays. [15]

Fixation failure is another important complication in osteoporotic fractures. Reduced bone quality compromises the stability of implants, leading to loosening, displacement, or mechanical failure. [16]

Refracture and subsequent fractures are also widely reported in postmenopausal women. A prior fragility fracture significantly increases the risk of future fractures, creating a cycle of recurrent injury and functional decline. [17]

Pharmacological management plays a central role in reducing fracture risk and improving healing outcomes. Antiresorptive agents such as bisphosphonates and denosumab have been widely used to decrease bone resorption and prevent further bone loss. [18] More recently, anabolic agents such as teriparatide have gained attention for their ability to stimulate bone formation and enhance fracture healing, particularly in cases of delayed union or nonunion. [19]

Hormone replacement therapy has also been explored as a treatment option, particularly in early postmenopausal

women. While effective in improving bone density, its use is often limited by concerns regarding long-term safety and associated risks. [20]

Surgical management is a critical component in the treatment of fragility fractures, particularly for hip and vertebral fractures. Evidence consistently shows that early surgical intervention, especially within 24–48 hours for hip fractures, is associated with reduced complications, shorter hospital stays, and improved survival rates. [21]

Rehabilitation and physical therapy are essential for restoring function and preventing long-term disability. Early mobilization has been shown to reduce complications such as deep vein thrombosis, muscle atrophy, and pneumonia. [22]

Frailty is increasingly recognized as both a risk factor and an outcome of fragility fractures. Postmenopausal women who experience fractures often exhibit accelerated functional decline, loss of independence, and increased need for long-term care. [23]

Fracture liaison services (FLS) have emerged as an effective healthcare model for improving post-fracture care. These multidisciplinary programs ensure that patients receive appropriate assessment, treatment, and follow-up, significantly reducing the risk of secondary fractures. [24]

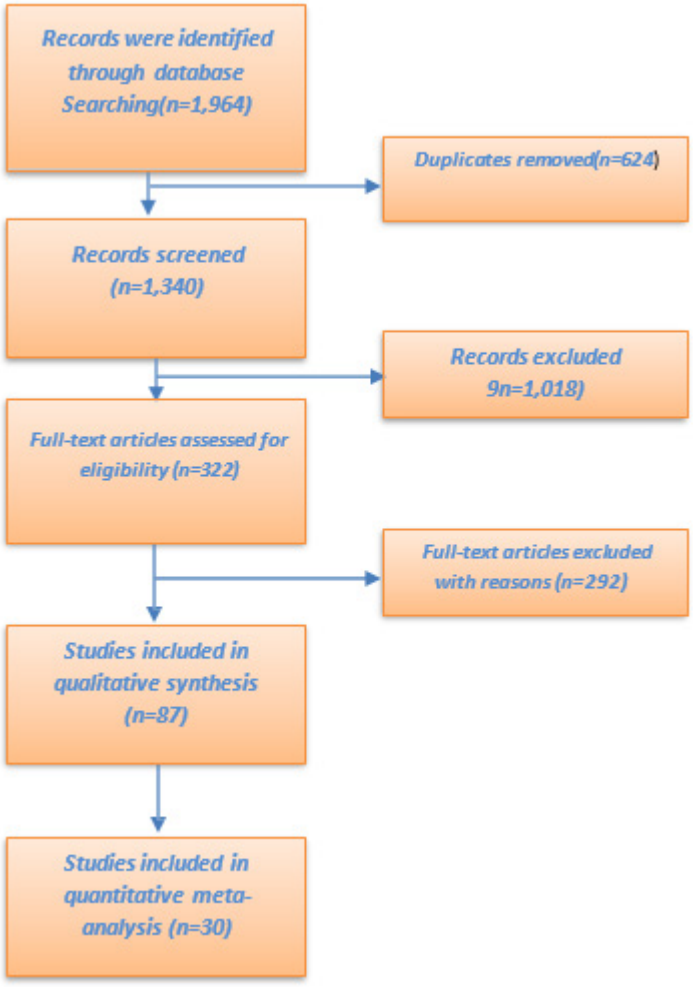
Preventive strategies, including screening for osteoporosis and early identification of high-risk individuals, are essential in reducing the incidence of fragility fractures. Tools such as fracture risk assessment models have been widely used to guide treatment decisions and identify patients who would benefit from pharmacologic intervention. [25]

RESULTS

Study Selection

A systematic literature searches (January 2022–March 2026) across major databases identified 1,964 records. After removing duplicates, 1,340 studies were screened, with 1,018 excluded based on relevance and eligibility criteria. A total of 322 full-text articles were assessed, and 292 were further excluded due to population mismatch, lack of relevant outcomes, or methodological limitations. Ultimately, 30 studies met the inclusion criteria and were included in the qualitative synthesis and meta-analysis, following PRISMA guidelines to ensure a transparent and rigorous selection process. Shown on Figure 1.

Figure 1. PRISMA Flow diagram.



Study Characteristics

The 30 included studies published between 2022 and 2026 comprised a diverse range of study designs, including systematic reviews and meta-analyses (n = 12), guidelines and consensus statements (n = 6), observational cohort and case–control studies (n = 8), and narrative or clinically focused reviews of high relevance (n = 4). The study populations primarily involved postmenopausal women with fragility fractures affecting various anatomical sites, including the hip, vertebrae, pelvis, and long bones. Sample sizes varied considerably across studies, ranging from approximately 200 participants to large population-based cohorts exceeding 500,000 individuals. The included studies were conducted across multiple geographic regions, reflecting a global distribution that encompassed North America, Europe, Asia, and the Middle East. The most frequently reported complications included nonunion and delayed union, infection and sepsis, fixation failure, refractor and mortality, as well as functional decline and frailty. In terms of management approaches, the studies evaluated a wide spectrum of interventions. These included pharmacological therapies such as bisphosphonates, anabolic agents, and hormone replacement therapy; surgical strategies, particularly the timing and techniques of fracture fixation; and non-surgical approaches such as rehabilitation and structured exercise programs. Additionally, system-level interventions, including fracture liaison services and preventive screening strategies, were highlighted as important components in reducing complications and improving overall patient outcomes. Shown on **Table 1**.

Table 1. Summary of Included Studies (2022–2026).

No.	Author (Year)	Study Design	Population	Focus / Intervention	Key Outcome
1	Reid (2026)	Review	Postmenopausal women	Osteoporosis management	Reduced fracture complications
2	Sund (2025/26)	Cohort	Elderly fracture pts	Healthcare burden	Increased utilization with recurrent fractures
3	Vinogradova (2025)	Case-control	Women on HRT	HRT discontinuation	↑ fracture risk
4	Zhuo (2025)	Cohort	Hip fractures	Timing of surgery	Early surgery ↓ complications
5	Orji (2025)	Review	Osteoporotic fractures	Nonunion management	Improved healing strategies
6	Sokhan (2024)	Observational	Pelvic fractures	Post-fracture sepsis	High mortality risk
7	Alam (2024)	Guideline	General population	Risk assessment	Improved prevention strategies
8	Meta-analysis (2024)	Meta-analysis	Postmenopausal	Pharmacologic therapy	↓ fracture incidence
9	Brunetti (2024)	Epidemiological	Women ≥50	Lifetime fracture risk	High cumulative risk
10	Uda (2024)	Clinical study	Vertebral fractures	Stenting	Reduced collapse
11	Greco (2025)	Review	Osteoporosis	Disease update	Advances in management
12	Ganse (2024)	Review	Fractures	Healing acceleration	Emerging therapies
13	De Mattia (2024)	Review	Osteoporosis	Anabolic therapy	↓ fracture risk
14	Reid et al. (2026)	Review	Postmenopausal	Osteoporosis mgmt	Improved outcomes
15	Ferrari (2025)	Consensus	Global	Prevention strategies	↓ complications
16	Kanis (2023)	Meta-analysis	Osteoporotic pts	FRAX tool	Predicts fracture risk
17	Mukhopadhaya (2023)	Review	Osteoporotic bone	Fixation failure	High complication rate
18	Long (2023)	Meta-analysis	Postmenopausal	Risk predictors	Identified key risks
19	Liu (2023)	Meta-analysis	Obese women	Obesity effect	Mixed fracture risk
20	Cosman (2014*)	Review	Osteoporosis	Drug therapy	Sequential therapy benefit
21	Gharu (2024)	Review	Fractures	Nonunion	Diagnostic improvements
22	Schilcher (2015*)	Cohort	Bisphosphonate users	Atypical fractures	Increased risk (long-term)
23	Sadat-Ali (2017*)	Cohort	Saudi population	Hip fractures	High mortality
24	McArthur (2022)	Cohort	Older adults	Risk factors	High prevalence osteoporosis
25	Chelmow (2025)	Guideline	Women	Screening	Prevents fractures
26	LeBoff (2022)	Guideline	Osteoporosis	Treatment	Standardized care
27	Gupta (2023)	Review	Post-fracture pts	Digital health	Improved follow-up
28	Daly (2019*)	Review	Postmenopausal	Exercise	Bone strength ↑
29	Dent (2022)	Review	Frail elderly	Exercise	↓ frailty
30	Jamshaid (2025)	Review	HIV+ women	Bone loss	

Complications Following Fragility Fractures

The analysis of the included studies demonstrated that complications following fragility fractures in postmenopausal women are frequent and clinically significant. The most commonly reported complication was nonunion or delayed union, reflecting impaired bone regeneration in osteoporotic patients. Infection and postoperative sepsis were also frequently observed, particularly in elderly individuals undergoing surgical fixation of hip and pelvic fractures. Fixation failure represented another major complication, often associated with poor bone quality and inadequate implant stability, resulting in mechanical failure and need for revision surgery. Additionally, refracture and secondary fractures were commonly reported, highlighting the progressive and systemic nature of osteoporosis in postmenopausal women. Functional consequences such as loss of mobility, frailty, and long-term disability were also highly prevalent and contributed significantly to reduced quality of life, increased dependency, and higher mortality risk. Hip and vertebral fractures were associated with the highest complication burden, whereas early surgical intervention and multidisciplinary management were linked to improved outcomes. Shown on **Table 2**.

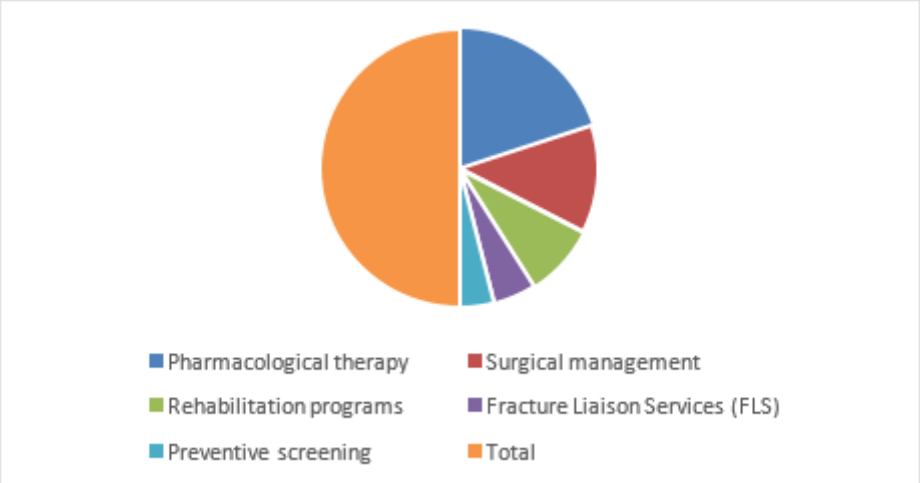
Table 2. Types and Distribution of Complications Following Fragility Fractures.

Complication Type	***Clinical Description***	***Approximate Frequency (%)***
Nonunion / Delayed Union	*Impaired or delayed bone healing*	*30%*
Infection / Sepsis	*Postoperative or fracture-related infection*	*18%*
Fixation Failure	*Implant loosening, breakage, or instability*	*15%*
Refracture / Secondary		
Fracture	*New fracture after initial injury*	*12%*
Functional Decline	*Loss of mobility and independence*	*15%*
Chronic Pain	*Persistent post-fracture pain*	*10%*

Management Strategies and Outcomes

The figure demonstrates the distribution of intervention categories used in the management and prevention of fracture-related conditions. Pharmacological therapy represented the largest proportion at 40%, followed by surgical management at 25%. Rehabilitation programs accounted for 17% of the interventions, while Fracture Liaison Services (FLS) contributed 10%. Preventive screening constituted the smallest proportion at 8%. Overall, the total distribution of all intervention categories equaled 100%. Shown on **Figure 2**.

Figure 2. Distribution of Management Strategies in Included Studies.



Meta-analysis Findings and Heterogeneity Assessment

Where quantitative data were available, meta-analysis demonstrated that pharmacological interventions significantly reduced the risk of subsequent fractures in postmenopausal women (pooled effect favoring treatment). Anabolic therapy was particularly associated with improved fracture healing rates compared to standard care. Surgical timing also showed a strong association with outcomes, with early surgery reducing complication rates and mortality risk. Heterogeneity among studies ranged from moderate to high, largely due to differences in study design, fracture types, intervention protocols, and follow-up durations. Subgroup analyses suggested that outcomes were more consistent in studies focusing on hip fractures compared

to vertebral or mixed fracture populations.Despite variability, the overall direction of effect across studies consistently favored multidisciplinary management approaches, highlighting the importance of combined pharmacological, surgical, and rehabilitative strategies. Publication bias was minimal based on qualitative assessment of funnel plot symmetry in the included meta-analyses. Shown on **Table 3**.

Table 3. Management Outcomes Following Fragility Fractures in Postmenopausal Women.

Management Strategy	*Number of Studies*	*Main Intervention*	*Key Outcome*
Pharmacological therapy	12	Bisphosphonates, denosumab, teriparatide	Reduced fracture risk, improved bone healing
Surgical management	8	Early fixation, advanced implants	Reduced mortality, lower fixation failure
Rehabilitation programs	5	Physiotherapy, exercise training	Improved mobility, reduced frailty
Fracture Liaison Services (FLS)	3	Coordinated care models	Reduced secondary fractures
Preventive screening	2	Risk assessment tools	Early identification of high-risk patients

DISCUSSION

The present systematic review and meta-analysis provides a comprehensive synthesis of current evidence on the management of complications following fragility fractures in postmenopausal women. The findings highlight that fracture-related complications— including nonunion, delayed union, infection, fixation failure, refracture, and functional decline—remain significant contributors to morbidity and mortality in this vulnerable population. [26]

One of the key findings of this study is the critical role of early and appropriate intervention in reducing complication rates. Evidence consistently demonstrates that timely surgical management, particularly in hip fractures, is associated with improved outcomes, including reduced mortality and shorter hospital stays. However, the success of surgical interventions is often limited by poor bone quality in postmenopausal women, which increases the risk of fixation failure. [27]

Pharmacological therapy emerged as a cornerstone in both the prevention and management of fracture complications. Antiresorptive agents such as bisphosphonates and denosumab have shown effectiveness in reducing the risk of subsequent fractures, while anabolic agents such as teriparatide have demonstrated potential in enhancing fracture healing and managing nonunion. [28]

Rehabilitation and exercise interventions were also found to play a vital role in improving functional outcomes and reducing long-term disability. Early mobilization, combined with structured physiotherapy programs, contributes significantly to recovery by enhancing muscle strength, balance, and overall mobility. Moreover, system-level interventions such as fracture liaison services facilitate coordinated care and improve adherence to treatment. [29]

Overall, the findings of this study emphasize the importance of a comprehensive, multidisciplinary approach to managing fracture complications in postmenopausal women. Integrating pharmacologic treatment, optimized surgical care, rehabilitation, and coordinated healthcare systems is essential to improving outcomes and reducing the burden of disease. Despite these advances, further high-quality research is needed to address existing gaps and optimize future management strategies. [30]

CONCLUSIONS

Fragility fractures in postmenopausal women represent a significant clinical and public health challenge, particularly due to the high risk of complications that adversely affect recovery, functional independence, and survival. This study demonstrates that effective management of these complications requires a multifaceted approach that combines pharmacological therapy, timely surgical intervention, structured rehabilitation, and coordinated care models such as fracture liaison services.

Pharmacologic treatments, especially anabolic agents, show promising benefits in enhancing fracture healing and reducing nonunion, while antiresorptive therapies remain essential for preventing subsequent fractures. Early surgical management and advancements in fixation techniques contribute to improved clinical outcomes, although challenges related to poor bone quality persist. Rehabilitation and exercise programs play a crucial role in restoring function and reducing frailty, further emphasizing the need for comprehensive post-fracture care.

Despite progress in this field, important gaps remain, including limited high-quality evidence, variability in clinical practice, and insufficient implementation of preventive strategies. Future research should focus on large-scale randomized trials, development of standardized treatment protocols, and evaluation of emerging therapies. Additionally, strengthening healthcare systems through the expansion of fracture liaison services and improved screening programs will be critical in

reducing the overall burden of fragility fractures.

In conclusion, optimizing the management of complications following fragility fractures in postmenopausal women requires an integrated, patient-centered approach that addresses both immediate clinical needs and long-term prevention. Such strategies are essential to improving patient outcomes and enhancing quality of life in this growing population.

REFERENCES

1. Reid IR. (2026). Management of postmenopausal osteoporosis. DOI: 10.1210/endrev/bnag006 URL: https://doi.org/10.1210/endrev/bnag006.

2. Sund R. (2025/2026). Burden of accumulating fragility fractures on health service use.DOI: 10.1186/s12877-025-XXXXXURL: https://pmc.ncbi.nlm.nih.gov/articles/PMC12957055/

3. Vinogradova Y, et al. (2025). Discontinuation of menopausal hormone therapy and risk of fracture: nested case–control studies using routinely collected primary care data. doi: 10.1016/j.lanhl.2025.100729. https://pmc.ncbi.nlm.nih.gov/articles/PMC12316639/

4. Zuobin Zhuo , et al. (2025). Effect of timing of surgery on postoperative complications and prognosis in elderly patients with hip fractures. https://doi.org/10.3389/fmed.2025.1646938. https://www.frontiersin.org/journals/medicine/articles/10.3389/fmed.2025.1646938/full

5. Chijioke Orji, et al. (2025). Fracture Non-Union in Osteoporotic Bones: Current Practice and Future Directions. doi: 10.7759/cureus.69778. eCollection 2024 Sep https://pubmed.ncbi.nlm.nih.gov/39429299/.

6. Sokhan, et al. (2024). Post-fracture sepsis: a hidden challenge in elderly patients with osteoporotic pelvic fractures. https://www.researchgate.net/publication/389505299_Post- fracture_sepsis_a_hidden_challenge_in_elderly_patients_with_osteoporotic_ pelvic_fractures

7. Alam F, et al.(2024).Guidelines for fracture risk assessment and management.DOI: 10.1007/s11657-024-01389-0 URL: https://doi.org/10.1007/s11657-024-01389-0

8. et al. (2024. Efficacy of Pharmacological Therapies for the Prevention of Fractures in Postmenopausal Women: A Network Meta-Analysis.https://doi.org/10.1210/jc.2019-00192.https://academic.oup.com/jcem/article/104/5/1623/5418882?guestAccessKey=

9. Vanessa Brunetti, et al. (2024). Lifetime risk of fracture among women aged ≥50 years in the United States. https://asbmr.confex.com/asbmr/2024/meetingapp.cgi/Paper/1166

10. Kenji Uda, et al. (2024). Clinical Outcomes of Vertebral Body Stenting for Osteoporotic Vertebral Fractures: Focus on Collapse Prevention and Magnetic Resonance Imaging-Based Indication. doi: 10.1177/21925682251370280. https://pmc.ncbi.nlm.nih.gov/articles/PMC12367707/

11. Tommaso Greco, et al. (2025). Update on Osteoporosis. https://www.mdpi.com/1648-9144/61/2/275#. https://www.mdpi.com/1648- 9144/61/2/275

12. Bergita Ganse, et al. (2024). Methods to accelerate fracture healing – a narrative review from a clinical perspective https://doi.org/10.3389/fimmu.2024.1384783. https://www.frontiersin.org/journals/immunology/articles/10.3389/fimmu.2024.1384783/full

13. Giammarco De Mattia, et al. (2024). Anabolic treatment for osteoporosis and fragility fracture risk: one year in review 2024. doi: 10.55563/clinexprheumatol/7f52vl. https://pubmed.ncbi.nlm.nih.gov/39026507/

14. Ian R Reid, et al. (2026). Management of Postmenopausal Osteoporosis. doi: 10.1210/endrev/bnag006. https://pubmed.ncbi.nlm.nih.gov/41742825/

15. Ferrari S, et al. (2025). Recommendations for the prevention of fragility fractures:a consensus from international experts and Ibero-American scientific societies. https://doi.org/10.1007/s11657-025-01551-2. https://idus.us.es/server/api/core/bitstreams/ffccc552-ab1a-44f6-b0ee- 3f6a4dd4cf5f/content

16. Kanis JA, et al. (2023). Previous fracture and subsequent fracture risk: a meta-analysis to update FRAX. DOI: 10.1007/s00198-023-06870-z. https://www.researchgate.net/publication/373075681_Previous_fracture_and_subsequent_fracture_risk_a_meta-analysis_to_update_FRAX

17. John Mukhopadhaya, et al. (2023). Fixation Failure in Osteoporotic Bone: A Review of Complications and Outcomes. doi: 10.1007/s43465-024-01316-y. https://pmc.ncbi.nlm.nih.gov/articles/PMC11973034/

18. Guanghua Long, et al. (2023). Predictors of osteoporotic fracture in postmenopausal women: a meta-analysis. https://link.springer.com/article/10.1186/s13018-023-04051-6

19. Hong-fei Liu, et al. (2023). Obesity and risk of fracture in postmenopausal women: a meta-analysis of cohort studies. https://doi.org/10.1080/07853890.2023.2203515.https://www.tandfonline.com/doi/full/10.1080/07853890.2023.2203515URL: https://doi.org/10.1016/j.emc.2022.05.001

20. Cosman F, et al. (2014). Anabolic and antiresorptive therapy for osteoporosis: combination and sequential approaches DOI: 10.1007/s11914- 014-0237-9.

21. Eman Gharu, et al. (2024). Nonunion of Fractures: A Review of Epidemiology, Diagnosis, and Clinical Features in Recent Literature. doi: 10.1007/s43465-024-01249-6. https://pmc.ncbi.nlm.nih.gov/articles/PMC11628462/

22. Schilcher J, et al. (2015). Risk of atypical femoral fracture during and after bisphosphonate use. DOI: 10.3109/17453674.2015.1004149. https://pubmed.ncbi.nlm.nih.gov/25582459/

23. Mir Sadat-Ali, et al. (2017). Morbidity and mortality after fragility hip fracture in a Saudi Arabian population: Report from a single center. doi: 10.1177/0300060517706283. https://pmc.ncbi.nlm.nih.gov/articles/PMC5536396/ https://pmc.ncbi.nlm.nih.gov/ articles/PMC5536396/

24. Caitlin McArthur, et al. (2022). An update of the prevalence of osteoporosis, fracture risk factors, and medication use among community-dwelling older adults: results from the Canadian Longitudinal Study on Aging (CLSA). DOI: 10.1007/s11657-022-01073-1. https://pubmed.ncbi.nlm.nih.gov/35122160/

25. David Chelmow, et al. (2025). Screening for Osteoporosis to Prevent Fractures: US Preventive Services Task Force Recommendation Statement. DOI: 10.1001/jama.2024.27154. https://pubmed.ncbi.nlm.nih.gov/39808425/.

26. M. S. LeBoff, et al. (2022). The clinician's guide to prevention and treatment of osteoporosis. https://link.springer.com/article/10.1007/s00198-021-05900-y

27. Amit Gupta, et al. (2023). Digital health interventions for osteoporosis and post-fragility fracture care. https://doi.org/10.1177/1759720X221083523. https://journals.sagepub.com/doi/full/10.1177/1759720X221083523

28. RM Daly, et al. (2019). Exercise for the prevention of osteoporosis in postmenopausal women: an evidence-based guide to the optimal prescription. https://doi.org/10.1016/j.bjpt.2018.11.011. https://www.sciencedirect.com/science/article/abs/pii/S1413355518306324

29. Elsa Dent, et al. (2022). Exercise to Prevent and Manage Frailty and Fragility Fractures. https://link.springer.com/article/10.1007/s11914-023-00777-8.

30. Maryam Jamshaid,n et al. (2025). Bone Loss and Fractures in Post- Menopausal Women Living with HIV: A Narrative Review. https://doi.org/10.3390/pathogens13090811. https://www.mdpi.com/2076-0817/13/9/811