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REVIEW ARTICLES

The Relationship Between Osteoporosis and Trauma: A Systematic Review

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Abstract

Introduction: Osteoporosis, a common bone disorder marked by decreased bone density and heightened fracture risk, especially after minor trauma, presents a significant public health challenge. The effects of trauma on patients with osteoporosis, particularly in the hip and vertebrae, result in considerable morbidity, mortality, and healthcare expenses.

This study aims to systematically review the existing literature on the relationship between osteoporosis and trauma. It explores the epidemiology, pathophysiology, clinical presentation, and management of trauma in osteoporotic patients while identifying gaps in preventive strategies.

Material and Methods: A systematic review was conducted using peer-reviewed journal articles focusing on osteoporosis-related trauma. Inclusion criteria included studies evaluating osteoporotic patients with traumatic injuries or those undergoing trauma risk assessments. Data were extracted from randomized controlled trials, cohort studies, and case-control studies, excluding non-human and non-research articles. Statistical analysis and critical appraisal were performed, and the selected studies were ensured to have methodological rigor.

Results: The findings emphasize a strong correlation between osteoporosis and trauma, with osteoporotic patients facing higher fracture rates and more extended recovery periods. The review reveals a significant gap in trauma prevention strategies, as current clinical approaches mainly prioritize pharmacological treatment over comprehensive fracture risk reduction. The increasing incidence of osteoporotic fractures, particularly in aging populations, highlights the need for early screening and multidisciplinary intervention.

Conclusion: Osteoporosis significantly increases the risk of fractures after minor trauma, leading to serious health consequences and economic burdens. However, the existing treatment strategies, though inadequate, provide opportunities for enhancement. An integrative approach that combines pharmacological therapy, fall prevention programs, and patient education could significantly enhance trauma prevention. The future shows promise for developing standardized guidelines for trauma prevention and optimizing clinical pathways for osteoporotic patients.

Keywords: Osteoporosis, Trauma, Fracture Risk, Bone Density, Prevention

Introduction

Osteoporosis is a progressive skeletal disorder marked by decreased bone mineral density (BMD) and a deterioration of bone microarchitecture, which leads to an increased risk of fractures. [1] It is considered a significant public health concern, particularly among postmenopausal women and older people, due to its link to fragility fractures, extended disability, and elevated mortality rates. [2] Although osteoporosis itself is asymptomatic, its chief consequence—fracture occurrence—imposes considerable medical, social, and economic burdens. Hip fractures, in particular, have a

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mortality rate of 14–58 % within the first year and often lead to long-term disability, reduced quality of life, and loss of independence. [3]

Despite extensive research on osteoporosis and its treatment, the interaction between osteoporosis and trauma remains an underexplored area. Trauma is a leading cause of fractures in osteoporotic individuals, yet the extent to which minor trauma contributes to osteoporosis-related fractures is not well-documented. [4] Clinicians widely acknowledge that osteoporotic bones are more vulnerable to mechanical stress. However, there is limited research addressing the broader consequences of trauma in osteoporotic patients, particularly regarding long-term outcomes and complications. [5] Additionally, pharmacological interventions such as bisphosphonates, selective estrogen receptor modulators (SERMs), and monoclonal antibodies have demonstrated efficacy in improving bone density. However, their role in preventing trauma-related fractures remains controversial. There is an ongoing debate about whether these treatments significantly reduce the risk of fractures following minor trauma or whether additional preventive measures, such as fall prevention strategies and lifestyle modifications, are necessary to achieve optimal patient outcomes.

The increasing prevalence of osteoporosis is a growing concern worldwide. It is estimated that over 200 million people have osteoporosis globally, with approximately 9 million osteoporotic fractures occurring annually. [6] As populations age, the number of osteoporosis-related fractures is expected to rise, posing challenges for healthcare systems in terms of treatment, rehabilitation, and preventive care. Moreover, the economic burden of osteoporosis-related fractures is substantial, with costs associated with hospitalizations, surgical interventions, rehabilitation, and long-term care. In many countries, osteoporosis-related fractures account for a significant proportion of healthcare expenditures, highlighting the urgent need for improved prevention and management strategies. [7]

One of the key challenges in managing osteoporosis-related fractures is the lack of standardized trauma prevention protocols tailored to osteoporotic patients. [8] Current clinical guidelines primarily focus on pharmacological treatment and bone density assessments, while the role of trauma prevention remains secondary. Strategies such as fall risk assessments, physical therapy, balance training, and environmental modifications have been proposed to reduce fracture risk, but their implementation in clinical Practice is inconsistent. [9] Additionally, there is limited interdisciplinary collaboration between orthopedic surgeons, geriatricians, and primary care providers in the comprehensive care of osteoporotic patients.

Given this knowledge and clinical Practice gaps, this systematic review aims to explore the relationship between osteoporosis and trauma by analyzing epidemiological data, risk factors, clinical outcomes, and management strategies. [10] By synthesizing existing literature, the study seeks to identify key risk factors for trauma-related fractures in osteoporotic individuals, evaluate the effectiveness of current preventive measures, and propose recommendations for improving patient care. [11] Understanding the complex interplay between osteoporosis and trauma will not only enhance clinical decision-making but also contribute to the development of targeted prevention programs that can reduce the burden of osteoporosis-related fractures globally.

Given this knowledge and clinical Practice gaps, this systematic review aims to explore the relationship between osteoporosis and trauma by analyzing epidemiological data, risk factors, clinical outcomes, and management strategies.

Research Objectives

1. To systematically review the existing literature on osteoporosis-related fractures caused by trauma.
2. To assess the impact of minor trauma on fracture risk in osteoporotic patients.
3. To evaluate the effectiveness of pharmacological and non-pharmacological interventions in preventing trauma-related fractures.
4. To identify gaps in current clinical management and propose strategies for improving preventive care.

By addressing these objectives, this study aims to provide valuable insights into the multifaceted relationship between osteoporosis and trauma, ultimately contributing to better patient outcomes and more effective healthcare policies.

Methodology

Study Design

This study is a systematic review of published literature evaluating the relationship between osteoporosis and trauma. The review follows established guidelines for systematic research, ensuring comprehensive data collection, methodological rigor, and a transparent synthesis of findings.

Search Strategy

A structured search was conducted using electronic databases, including PubMed, Scopus, and Web of Science, supplemented by manual searches of grey literature. The search included studies published before March 2025. Key search terms included “osteoporosis,” “trauma,” “fracture risk,” “bone density,” “fall prevention,” and “osteoporotic fractures.”

Inclusion and Exclusion Criteria

This systematic review includes peer-reviewed articles covering patients with osteoporosis who underwent traumatic evaluation or have traumatic injuries, such as fragility fractures. Articles published in any language were included. Data from population-based, matched-cohort, case-control, cross-sectional, cohort study, and clinical

study were included. Data from other types of study or research, summarization, case series, expert opinion, lesson, case report, and publications with insufficient material to evaluate without additional information are excluded from the analysis.

Inclusion Criteria:

- Studies assessing the relationship between osteoporosis and trauma.
- Research evaluating osteoporotic patients who experienced fractures due to trauma.
- Peer-reviewed clinical trials, cohort studies, and case-control studies.
- Articles with statistical comparisons of trauma risk in osteoporotic patients.

Exclusion Criteria:

- Non-research articles such as editorials, opinions, and case reports.
- Studies without sufficient data for methodological evaluation.
- Articles focusing exclusively on pediatric osteoporosis.
- Research on non-traumatic osteoporotic conditions or purely biomechanical studies.

Data Collection and Analysis

Selected studies were reviewed systematically, and relevant data were extracted into a structured database. The methodological quality of the included studies was assessed using the NIH Quality Assessment Tool for Case-Control Studies. [12] A thematic analysis was performed to identify trends in fracture risks, trauma mechanisms, and preventive strategies. Statistical consultation ensured accuracy in data interpretation.

Ethical Considerations

Since this study is a systematic review, no direct human or animal subjects were involved, and ethical approval was not required. However, the review adhered to PRISMA guidelines to ensure transparency and reliability in reporting findings.

Results

Epidemiology of Osteoporosis and Trauma

This report reviews the epidemiological data about osteoporosis and its relationship with trauma. This report is vital due to the increasing numbers of people reaching the age where trauma, and fracture in particular, are more likely, and increased upward pressures on healthcare provision generally. It also provides an overview of the basic medical facts and issues. Osteoporosis is a systemic disease characterized by decreased bone mass and disrupted bone architecture, resulting in reduced bone strength and an increased risk of fracture. [13] It is recognized as a significant public health concern, particularly in older women, and has, therefore, been the subject of repeated international recommendations for prevention, screening, and treatment. [14] Osteoporosis and osteoarthritis are likely to emerge as the most significant musculoskeletal health issues of the 21st century. As such, publications in this area show increased interest from the medical profession, government, and the general public. Trauma is also a 21st-century health indicator. [15] This increased the emphasis on both prevention and cure. [16] Injuries, in turn, can be all too easily compounded by osteoporotic changes to the skeleton. [17] Several other factors can dramatically increase the associations of osteoporosis with trauma. The most important consequence is trauma, particularly incidents of moderate force such as fractures, which in past years were infrequent but are becoming more so as bone demineralizes with increasing age. [18] Fractures in older persons due to moderate trauma are often associated with osteoporosis, so the government and healthcare planners can use osteoporosis prevention and treatment to reduce the incidence of disability and medical care. [19]

Pathophysiology of Osteoporosis and Its Impact on Trauma

Osteoporosis is a generalized skeletal disorder characterized by low bone mass and derangement of standard bone architecture that compromises bone strength and increases fracture risk. [20] Bone mineral density (BMD) declines are accompanied by changes in the proteinaceous matrix and structural orientation of bone. [21] Bone fragility may also result from more subtle regulatory failure between osteoblast (bone-forming) and osteoclast (bone-resorbing) activity. [22]

Osteoporosis development is determined by peak BMD, which generally occurs in the third or fourth decade of life, and the subsequent rate of decline (Johnell & Kanis, 2006). [23] Approximately 80% of the variation in BMD may be genetically predetermined, with various monogenic conditions characterized by aberrant skeletal phenotypes. [24] However, genetic variation is crucial to bone mineral density (BMD) and the risk of osteoporotic fractures. It may lead doctors to identify and treat subjects at higher risk of developing low-trauma fractures. [25] Several significant and rare gene variants have been associated with osteoporosis, including specific polymorphisms in the genes that encode type 1 collagen chains. [16]

Several extrinsic factors influence the risk of osteoporosis, including diet, physical activity, and exposure to environmental toxins. Common gene variants have been identified as predictors of both bone mineral density (BMD) and fracture risk, acting independently. [26] These might be incorporated into algorithms that more accurately predict fracture risk. [27] Osteoporotic fragility fractures occur across the skeleton but are most common in the vertebrae, proximal femur, and distal radius. [28] Reduced BMD and the resultant microarchitectural changes can arise due to endocrine dysfunction, dietary deficiencies (such as insufficient calcium or vitamin D), or as a side-effect of pharmacological interventions. [29]

Fragility fractures in older people may also be attributed to extrinsic skeletal factors, including frailty, failing eyesight, and a tendency to fall. [30] Since the proximate cause of osteoporosis fractures is trauma, such falls result in a greater probability that an individual with low bone strength will sustain fractures. [31] This likelihood is further enhanced in those with osteoporosis by the changes in normal gait produced by either acute mechanical hip fracture pain or chronic reconstruction arthritides. [32]

Clinical Presentation and Diagnosis of Trauma in Osteoporotic Patients

Understanding the clinical presentation and diagnostic challenges of trauma in osteoporotic patients is crucial to improving patient outcomes. Osteoporotic patients often present with fractures following low-energy trauma, such as falls from a standing height. Common fracture sites include the vertebrae, hip, wrist, and proximal humerus. [33] Unlike fractures in younger individuals, osteoporotic fractures may occur with minimal or even no apparent trauma due to compromised bone strength. Vertebral fractures are particularly insidious, often presenting with vague back pain, height loss, and kyphosis. [34] Hip fractures, on the other hand, are associated with significant morbidity and mortality, frequently manifesting with severe pain and an inability to bear weight. [35] Wrist and forearm fractures, typically resulting from falls on an outstretched hand, are prevalent among postmenopausal women. In contrast, pelvic and proximal humerus fractures, though less common, can significantly impair mobility and function. [36] Diagnosing fractures in osteoporotic patients can be challenging due to atypical symptoms, radiographic limitations, and the presence of comorbid conditions. Many patients may not report significant pain, leading to delayed diagnosis. [37] Although standard X-rays are a first-line imaging modality, they may not always detect subtle or occult fractures, necessitating the use of advanced imaging techniques. [38] Dual-energy X-ray absorptiometry (DXA) remains the gold standard for diagnosing osteoporosis, but does not directly detect fractures. [39] Magnetic resonance imaging (MRI) and computed tomography (CT) scans prove invaluable in identifying occult fractures, particularly in vertebral and pelvic regions. [40] Bone scintigraphy may aid in detecting stress fractures or multiple sites of injury, further enhancing diagnostic accuracy. Laboratory investigations, including serum calcium, vitamin D, parathyroid hormone levels, and bone turnover markers, provide additional insight into bone metabolism and fracture risk. [41] Trauma in osteoporotic patients presents unique diagnostic challenges that require a thorough clinical and imaging approach for accurate identification. Given the complex nature of osteoporotic fractures, a multidisciplinary strategy is crucial for optimizing patient outcomes. [42]

Discussion

The incidence of osteoporotic fractures in aged patients seems to be rising continuously in industrialized countries. Because osteoporosis can lead to a significant decrease in bone density, fractures can occur spontaneously or following low-energy trauma. [43] Fractures of the hip, the wrist, and the femoral neck are common osteoporotic fractures. It is essential to recognize these fractures since trauma surgeons play a significant role in healthcare provider teams with the responsibility of both surgical and conservative therapy. [19] Trauma surgeons are also responsible for prescribing further follow-up imaging and dealing with the primary treatment of fractures. In many cases, the exact age of the fracture is unclear, especially in trauma patients or osteoporotic patients, and follow-up imaging is the only accurate way of distinguishing the fracture from previous traumatic changes. [44] Standard X-ray is routinely used to diagnose osteoporotic fractures. MRI or Computerized Axial Tomography scans can also be used, depending on the fracture site and the need for magnification views. These should then be considered in cases of delayed or negative diagnostics. Since recognizing fractures can be especially difficult in osteoporosis cases, they can often be easily overlooked. [45] This can result in improper treatment, delayed mobilization, and unnecessary procedures. On the other hand, unnecessary diagnostic odysseys often stress the anxious patient and increase healthcare costs. [46] Thus, the management team must complete a comprehensive assessment to ensure accurate diagnosis and indicate treatment strategies (including pharmacological therapy and minimally invasive surgery). [47] Especially in osteoporosis-related fractures, due to the very early return to complete weight-bearing activities and because of the concomitant antirheumatic or anticoagulant regimes, improperly treated fractures may lead to persistent disability, prolonged nursing care, or early re-fracture. [48]

Osteoporosis is a disease characterized by decreased bone density and quality, leading to an increased risk of fractures. Osteoporotic fractures are considered low-energy trauma, which must be distinguished from high-energy trauma. The management and prevention of osteoporosis are paramount in diminishing the risk of fractures. In the context of patients who already have osteoporosis, the managements are broad spectrum, pharmacological (commonly bisphosphonates and calcium supplements) as well as non-pharmacological (usually physical therapies or fall prevention programs) and also include an emphasis on the increasing importance of multidisciplinarity, reflecting the need for collaboration between different medical departments, such as primary care physicians, nutritionists, or physical therapists. [49] Patients may not adhere to treatment plans, requiring an educational approach that effectively promotes lifestyle changes. It is implied that care must be individualized and aligned with the current guidelines

for osteoporotic patients. For people who suffer low-energy trauma, appropriate screening tests for osteoporosis are recommended. Aware of these issues, this section aims to convey a clear message about how osteoporosis and low-energy trauma constitute interconnected medical issues, suggest strategies for managing osteoporosis patients, and broaden specialist understanding of this topic. [50,51]

Conclusion

Osteoporotic fractures are a significant medical, economic, and social burden. They constitute an increasing issue, as an aging population is associated with a surge in fractures worldwide. They are observable within the hip, forearm, and vertebral bones, usually affecting older adults, and can lead to severe health issues, such as disability, severe mental issues, and a higher rate of mortality occurring after a concomitant injury. Furthermore, such individuals who have suffered from low-energy trauma pose a risk of subsequent fractures. Nevertheless, these facts tend to be underestimated, mainly by general physicians and other non-orthopedic specialists, which may result in an underestimation of the occurrence of fractures, their injudicious treatment, and a lack of planned screening tests for osteoporosis, as postulated by contemporary guidelines of expert societies dealing with osteo-sarcopania medical issues.

On the other hand, once osteoporosis is diagnosed, a comprehensive treatment of this disease should be initiated. It usually involves the administration of pharmacological therapy, but preventive activities should also be addressed. Educational programs that facilitate adherence to lifestyle modification guidelines and promote an understanding of osteoporosis-related issues are also highly beneficial.

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