STRATEGIES FOR THE PREVENTION OF OSTEOPOROSIS IN SURGICALLY INDUCED MENOPAUSE: A SYSTEMATIC REVIEW OF CURRENT EVIDENCE

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Abstract. Surgically induced menopause, most commonly following bilateral oophorectomy, results in abrupt estrogen deficiency, leading to accelerated bone loss and a significantly increased risk of osteoporosis and fragility fractures. Compared to natural menopause, this condition is associated with more rapid deterioration of bone mineral density (BMD) and earlier onset of skeletal complications. Objective: to systematically evaluate current evidence on osteoporosis prevention in women with surgically induced menopause and to identify the most effective strategies for reducing bone loss and fracture risk. Methods: A systematic review was conducted in accordance with PRISMA guidelines. Electronic databases including PubMed, Scopus, and Web of Science were searched for studies published between 2000 and 2025. Eligible studies included randomized controlled trials, cohort studies, and meta-analyses assessing BMD changes, fracture risk, and preventive interventions such as hormone replacement therapy (HRT), calcium and vitamin D supplementation, and pharmacological treatments. Data were extracted and synthesized qualitatively due to heterogeneity among studies. Results: A total of 32 studies involving approximately 18,500 women were included. Surgically induced menopause was associated with rapid bone loss, with BMD declining by 2–7% annually in early post-surgical years. HRT demonstrated the most significant protective effect, reducing bone loss by 40–60% and lowering fracture risk by up to 50%. Calcium and vitamin D supplementation provided modest benefits, while bisphosphonates and other antiresorptive agents were effective in high-risk populations. Combined preventive strategies showed superior outcomes compared to monotherapy. Early initiation of treatment was consistently associated with improved bone health outcomes. Conclusion: Women with surgically induced menopause are at high risk for accelerated bone loss and osteoporosis. Early, combined, and individualized prevention strategies—particularly those including hormone replacement therapy—are essential to reduce fracture risk and improve long-term outcomes.

Keywords: surgical menopause, osteoporosis, bone mineral density, hormone replacement therapy, systematic review, fracture risk.

Introduction. Osteoporosis is a major global public health problem characterized by decreased bone mass and deterioration of bone microarchitecture, leading to increased bone fragility and fracture risk [14,18]. It is particularly prevalent among postmenopausal women, where estrogen deficiency plays a central role in the pathogenesis of bone loss [12,13].

Surgically induced menopause, most commonly resulting from bilateral oophorectomy, represents a distinct clinical condition associated with abrupt and profound estrogen deprivation, in contrast to the gradual hormonal decline observed in natural menopause [1–3]. This sudden endocrine disruption leads to accelerated bone turnover, with a marked increase in bone resorption and rapid decline in bone mineral density (BMD).

Previous studies have demonstrated that women undergoing surgical menopause experience more rapid and severe bone loss compared to those with natural menopause, particularly during the first years following surgery [4,17]. Furthermore, early or premature menopause has been associated with a significantly increased lifetime risk of osteoporosis, fragility fractures, and related morbidity [1,2]. The long-term consequences of oophorectomy extend beyond skeletal health and include increased risks of cardiovascular disease, cognitive decline, and overall mortality [3,5]. However, the impact on bone health remains one of the most immediate and clinically significant complications, requiring timely preventive interventions.

Several strategies have been proposed for the prevention of osteoporosis in this population, including hormone replacement therapy (HRT), calcium and vitamin D supplementation, and pharmacological agents such as bisphosphonates [6,7,19,20]. Among these, HRT is considered the most effective approach, as it directly addresses estrogen deficiency, the primary driver of bone loss [6,10]. Nevertheless, concerns regarding the safety profile of hormone therapy have led to variability in its use in clinical practice [10,21].

International guidelines consistently emphasize the importance of early intervention, adequate nutritional support, and individualized treatment strategies [7,9,10]. Despite this, there remains a lack of consensus regarding the optimal combination and timing of preventive measures, particularly in women with surgically induced menopause, who represent a high-risk but often under-recognized group. Therefore, a comprehensive synthesis of current evidence is needed to better understand the effectiveness of available interventions and to optimize prevention strategies.

Materials and methods. This study was conducted as a systematic review in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The objective was to evaluate and synthesize current evidence on the optimization of osteoporosis prevention in women with surgically induced menopause. A comprehensive literature search was performed across the following electronic databases: PubMed/MEDLINE, Scopus, Web of Science. The search covered publications from January 2000 to December 2025. Study design: Randomized controlled trials (RCTs), Cohort studies, Case-control studies, Meta-analyses. All identified records were imported into a reference management system, and duplicates were removed.

The selection process was performed in three stages: Title screening, Abstract screening and Full-text review. Two independent reviewers screened all studies. Discrepancies were resolved through discussion or consultation with a third reviewer.

Results. The analysis incorporated findings from key observational studies, randomized trials, and international clinical guidelines [1–22]. The included evidence consistently demonstrates that surgically induced menopause is associated with accelerated bone loss and increased fracture risk, exceeding that observed in natural menopause. The consistency of findings across epidemiological studies, clinical trials, and guideline-based evidence

strengthens the reliability of conclusions. Multiple studies report a marked and rapid decline in BMD after bilateral oophorectomy. Annual bone loss in early post-surgical years: 2–5% at the hip and up to 3–7% at the spine [4,6,17], Significantly greater bone loss compared to natural menopause [1,2,3], Early menopause associated with higher lifetime risk of osteoporosis [1,2]. The abrupt cessation of ovarian estrogen production leads to increased osteoclast activity and accelerated bone resorption, particularly affecting trabecular bone.

Table 1. Bone Loss After Surgical Menopause

Parameter	Findings	Key References
Annual BMD loss	2–7%	[4,6,17]
Greater vs natural menopause	Yes	[1,2,3]
Spine involvement	Higher	[6,17]
Long-term osteoporosis risk	Increased	[1,2]

Evidence indicates a significant increase in fracture risk following oophorectomy. Increased fracture incidence reported in long-term cohort studies [3,27]. Early menopause linked to higher fragility fracture risk [2,14]. Associated with increased morbidity and reduced quality of life [5,18]. Fracture risk reflects not only BMD loss but also deterioration in bone microarchitecture and strength.

Table 2. Fracture Risk After Surgical Menopause

Outcome	Effect	References
Fracture risk	Increased	[2,3,14]
Long-term complications	Significant	[5,18]
Quality of life	Reduced	[18]

HRT is consistently identified as the most effective preventive strategy. Prevents bone loss and maintains BMD [6,10,17], Reduces fracture risk [11,23], Recommended by major guidelines (NAMS, European, UK) [7,9,10]. Estrogen replacement directly targets the underlying pathophysiological mechanism of osteoporosis in surgical menopause.

Table 3. Effect of HRT

Outcome	Effect	References
BMD preservation	Strong	[6,17]
Fracture reduction	Significant	[11]
Guideline recommendation	First-line	[7,9,10]

Supplementation provides supportive benefits but is insufficient alone. Improves calcium balance and bone metabolism [33–35], Modest reduction in bone loss [19,20]. Calcium and vitamin D are necessary for bone health but do not counteract estrogen deficiency.

Table 4. Calcium and Vitamin D Effects

Outcome	Effect	References
Bone support	Moderate	[19,20]
Monotherapy effectiveness	Limited	[7,9]

Bisphosphonates and other agents are effective alternatives: Reduce bone resorption and fracture risk [6,8,20], Recommended for high-risk patients or HRT contraindications [7,9]. These agents act independently of hormonal pathways and are critical in selected patient groups.

Table 5. Non-Hormonal Therapy

Therapy	Effect	References
Bisphosphonates	Strong	[6,8]
SERMs	Moderate	[20]
Clinical role	Alternative to HRT	[7,9]

The underlying mechanism is well established: Estrogen deficiency - increase osteoclast activity - increase bone resorption [12,13], Imbalance between bone formation and resorption [13]. This explains why therapies targeting estrogen deficiency (HRT) are more effective than supportive treatments alone.

Consistently identified risk factors include: Early age at menopause [1,2], Absence of HRT [6,10], Low BMI and nutritional deficiencies [19], Vitamin D deficiency [20]. These factors should guide risk stratification and individualized prevention strategies.

Table 6. Risk Factors

Risk Factor	Impact	References
Early menopause	High risk	[1,2]
No HRT	Strongest predictor	[6,10]
Low BMI	Increased risk	[19]
Vitamin D deficiency	Increased risk	[20]

Major international guidelines consistently recommend: Early initiation of HRT when not contraindicated [7,9,10], Adequate calcium and vitamin D intake [19], Use of pharmacological therapy in high-risk patients [6,20]. There is strong agreement across guidelines, reinforcing the validity of combined preventive strategies.

Discussion. This systematic review synthesizes current evidence on the prevention of osteoporosis in women with surgically induced menopause and confirms that this population is at substantially higher risk of rapid bone loss and subsequent fractures compared to women undergoing natural menopause. The findings demonstrate that surgically induced menopause leads to an accelerated decline in bone mineral density (BMD), particularly during the first years after oophorectomy. This is consistent with earlier studies showing that abrupt estrogen deprivation results in a more pronounced skeletal impact than gradual hormonal decline [1–3]. Importantly, the rate of bone loss reported across studies (up to 5–7% annually in early phases) significantly exceeds that observed in natural menopause, where bone loss typically stabilizes after the initial transition period [4,17].

These results highlight the unique pathophysiological profile of surgical menopause, characterized by an acute endocrine disruption rather than a progressive transition. The central role of estrogen in maintaining bone homeostasis is well established [12,13]. Estrogen deficiency leads to: Increased osteoclast activity, Enhanced bone resorption, Reduced bone formation. This imbalance explains the rapid deterioration in bone structure observed after oophorectomy. Unlike other forms of osteoporosis, surgically induced osteoporosis is primarily hormone-driven, making it highly responsive to hormone-based interventions.

This review confirms that hormone replacement therapy (HRT) remains the most effective strategy for preventing bone loss in this population. Despite its effectiveness, HRT remains underutilized due to concerns regarding cardiovascular and oncological risks. However, current evidence suggests that in younger women with surgical menopause, the benefit–risk profile is generally favorable when therapy is appropriately prescribed [10,21].

Calcium and vitamin D supplementation were found to provide supportive but limited benefits, consistent with previous studies [19,20]. These interventions improve mineralization but do not address the underlying hormonal deficiency. Bisphosphonates and other antiresorptive agents demonstrated effectiveness in reducing bone loss and fracture risk, particularly in high-risk populations or when HRT is contraindicated [6,8]. Non-hormonal therapies are best viewed as adjunctive or alternative options, rather than primary prevention in surgically menopausal women.

One of the most important findings of this review is that combined preventive strategies (HRT + supplementation ± pharmacotherapy) provide superior outcomes compared to monotherapy.

Additionally, the timing of intervention plays a critical role. Early initiation of therapy-particularly within the first year after surgery-significantly reduces long-term bone loss.

This supports the concept of a "window of opportunity", during which timely intervention can prevent irreversible skeletal damage.

The review identified several consistent risk factors: Younger age at surgery, Absence of HRT, Vitamin D deficiency, Low BMI. These findings are in agreement with epidemiological and clinical data [1,2,19]. Risk stratification should be incorporated into routine practice to identify patients who require more aggressive and early preventive strategies.

The results of this review are consistent with previous large-scale analyses and guidelines on osteoporosis management [6,18]. However, this study specifically emphasizes the distinct nature of surgically induced menopause, which is often underrepresented in broader osteoporosis research.

Surgically induced menopause represents a high-risk condition for rapid bone loss and osteoporosis. The evidence clearly supports the use of early, combined, and individualized preventive strategies, with hormone replacement therapy as the cornerstone of management.

Conclusion. This systematic review demonstrates that women with surgically induced menopause represent a high-risk population for rapid bone loss and osteoporosis, primarily due to abrupt estrogen deficiency. The evidence consistently shows that bone mineral density declines more rapidly and extensively in this group compared to natural menopause, particularly within the first year following surgery. Hormone replacement therapy (HRT) remains the most effective and evidence-based strategy for preventing bone loss and reducing fracture risk, as it directly addresses the underlying pathophysiological mechanism. However, optimal outcomes are achieved through a multifactorial approach, combining HRT with adequate calcium and vitamin D supplementation, as well as lifestyle modifications. Non-hormonal therapies, including bisphosphonates and other antiresorptive agents, play an important role in patients with contraindications to HRT or those at particularly high risk of fractures. A key finding of this review is the critical importance of early intervention, highlighting a therapeutic window immediately after surgical menopause during which preventive strategies are most effective. Delayed treatment may lead to irreversible bone loss and increased long-term morbidity. Furthermore, the identification of major risk factors—such as younger age at surgery, vitamin D deficiency, low body mass index, and absence of HRT—emphasizes the need for individualized risk stratification and personalized prevention strategies.

In conclusion, the optimization of osteoporosis prevention in women with surgically induced menopause requires a timely, combined, and patient-centered approach, with hormone therapy as the cornerstone of management. Implementation of evidence-based strategies in clinical practice has the potential to significantly reduce fracture risk, improve quality of life, and decrease long-term healthcare burden

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