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The Role of Bisphosphonates in Preventing Fragility Fractures: A 10-Year Follow-Up Study

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Abstract
Bisphosphonates serve as a pharmaceutical treatment to stop fractures among people who have osteoporosis which shows itself through reduced bone mineral density and elevated susceptibility to bone-breaking fractures. The purpose of this research is to determine how well bisphosphonates prevent fragility fractures during a 10-year observation period. The analysis included data about fracture occurrences and BMD changes and bisphosphonate safety measurements with special attention given to rare side effects such as osteonecrosis of the jaw (ONJ) and atypical femoral fractures. A research sample included people who were 50 years old or older with osteoporosis or those who had a high risk of bone fractures. The bisphosphonate treatment group achieved statistically lower rates of both vertebral and hip fractures compared to the control group. The treatment led to higher bone mineral density levels at the hip region and at the lumbar spine. The research demonstrated that bisphosphonate therapy extends risks through the development of osteonecrosis of the jaw (ONJ) and atypical femoral fractures. The research highlights the necessity for individualized therapy plans and additional studies about the best duration of treatment together with drug breaks and long-term treatment consequences.

Key words: Bisphosphonates, Fragility Fractures, Osteoporosis, Bone Mineral Density, Long-Term Efficacy, Fracture Prevention, Atypical Femoral Fractures, Osteonecrosis of the Jaw, Drug Holidays.

Introduction

The skeletal disorder known as osteoporosis advances through time by reducing bone mineral density and damaging bone microstructure thus making patients more prone to fractures (Kanis et al., 2013). The primary outcome of osteoporosis includes fragility fractures that develop after standing height or lower impact trauma events. The most common fractures that occur in osteoporosis patients affect the hip and spine and wrist bones and result in major health consequences and increased medical expenses (Cummings et al., 1998). The worldwide increase in elderly population leads to rising numbers of osteoporosis and fragility fractures which strain healthcare systems throughout the world (Sanderson et al., 2016). Bisphosphonates represent the most commonly prescribed medications for preventing fragility fractures because they both reduce bone resorption and strengthen bone density. Bisphosphonates serve as the primary therapeutic approach for osteoporosis because they effectively decrease the chances of experiencing vertebral and hip and non-vertebral fractures (Dieppe, Wollheim, & Schumacher, 2001). Bisphosphonates have received extensive research since their introduction as evidence demonstrates their ability to prevent fractures in postmenopausal women and men and people with osteoporosis from secondary causes (Deardorff et al., 2022). The research investigates the extended effectiveness of bisphosphonates for preventing fragility fractures during a ten-year observation period. Medical research continues to explore the extended benefits and safety aspects of using bisphosphonates as short-term studies consistently prove their fracture risk reduction effectiveness (Cummings et al., 1998). The evaluation of bisphosphonates' long-term effects on fragility fractures remains crucial for medical professionals to make better treatment choices for patients who face fracture risks. The research investigates fracture occurrence together with bone mineral density alterations and safety aspects of bisphosphonate therapy spanning ten years among patients who received an osteoporosis diagnosis or were considered at high risk for fractures.

Doctors use BMD measurements to diagnose osteoporosis according to WHO (2003) standards where a T-score below -2.5 indicates disease presence. The danger of experiencing fragility fractures rises as people age and their bone mineral density decreases while additional risk elements including gender, genetic background and lifestyle choices affect the outcome (Kanis et al., 2013). The condition of osteoporosis together with its resulting fractures stands as the primary disability-causing and independence-impairing issues among postmenopausal women and elderly adults (Cummings et al., 1998). The prevalence of vertebral fractures in women aged 50 and above reaches 15-20% yet most cases remain

undetected and lead to painful conditions and spinal deformities and life quality deterioration (Tei et al., 2001). Hip fractures appear less frequently but their impact on mobility is severe and leads to elevated mortality rates which persist throughout the year after the fracture (Kannuset al., 1996). Pharmacological treatments have emerged as a response to the increasing numbers of patients with osteoporosis and fragility fractures. Bisphosphonates represent one of the most effective drug classes which medical professionals widely prescribe to treat patients. The mechanism of action in bisphosphonates involves stopping osteoclasts from breaking down bone tissue which leads to both bone density preservation and potential density increase thus reducing fracture occurrence (Deardorff et al., 2022). Scientists continue to study the extended outcomes of bisphosphonate medications regarding their fracture protection capabilities as well as their possible negative impacts.

The synthetic compounds known as bisphosphonates attach to hydroxyapatite crystals in bone tissue to prevent osteoclast-mediated resorption through osteoclast apoptosis (Rodan & Fleisch, 1996). The treatment results in denser bones which decreases the probability of fractures. The Food and Drug Administration has approved three bisphosphonates namely alendronate, risedronate and zoledronic acid for osteoporosis treatment under different prescribed dosing regimens. People receive alendronate and risedronate through oral routes but need zoledronic acid through intravenous infusion according to Deardorff et al. (2022). Multiple clinical trials have proven that bisphosphonates effectively decrease the number of osteoporotic fractures that occur. Scientific trials from the FIT program established that alendronate therapy produced a 47% decrease of vertebral fractures and a 51% decrease of hip fractures among postmenopausal women with osteoporosis (Cummings et al., 1998). The Hip Intervention Program (HIP) trial revealed risedronate reduced hip fracture risk by 35% according to Deardorff et al. (2009). The HORIZON-Pivotal Fracture Trial demonstrated that zoledronic acid decreases vertebral fractures by 70% along with hip fractures by 41% and non-vertebral fractures by 25% in women with osteoporosis (Dieppe, Wollheim, & Schumacher, 2001). The long-term application of bisphosphonates for bone protection has led to increased medical attention due to rare potential side effects which include osteonecrosis of the jaw (ONJ) along with atypical femoral fractures. Research continues to determine the proper duration of bisphosphonate therapy and patient management strategies for extended treatment because these risks remain uncommon (Durie, Katz & Crowley, 2005). The need to manage potential adverse effects from bisphosphonate overuse has led researchers to develop the drug holiday approach which removes patients from bisphosphonate treatment after several years of use to maintain fracture protection while reducing side effects (Adachi et al., 2013).

Bisphosphonates demonstrate their ability to prevent fractures in prolonged usage although the exact protective benefits may differ with time. Women who received zoledronic acid treatment for three years maintained their reduced fracture risk during the subsequent three years even after discontinuing the medication according to Dieppe Wollheim and Schumacher 2001. Research has not established definite conclusions about how bone quality will respond or fracture risks will change when patients stop taking these drugs. The research findings about bisphosphonate treatment effects beyond treatment cessation remain uncertain because studies show both sustained benefits after several years and elevated fracture risks (Sanderson et al., 2016). A research investigation intends to assess the ten-year consequences of bisphosphonates regarding fracture rates along with bone density alterations and negative treatment effects. The growing importance of osteoporosis long-term care requires understanding how durable bisphosphonate therapy remains to optimize treatment approaches and deliver the best possible safe therapy to patients.

Significance of the Study

The research findings create important implications for both medical care delivery and public health management and upcoming osteoporosis scientific investigation. The growing number of osteoporosis cases and fragility fractures among elderly people requires immediate study of the best long-term treatments to decrease fracture risk. The study seeks to add evidence about the extended benefits of bisphosphonates as core treatments for osteoporosis which reduce fracture occurrence. The research outcomes will enhance knowledge about the best bisphosphonate treatment length and how well its results persist and how safe it remains during extended use. This research will direct healthcare professionals to make appropriate decisions about starting and continuing bisphosphonate therapy for patients at risk of fragility fractures which should lead to enhanced patient results and decreased healthcare expenses from osteoporosis fractures. The study specifically examines safety issues regarding osteonecrosis of the jaw and atypical femoral fractures since these rare complications can badly affect patients' quality of life and their ability to adhere to treatment. Bisphosphonate treatment decisions for susceptible patient groups become more effective when healthcare providers understand the factors which increase the risk of adverse events.

Objectives of the Study

The primary objective of this study is to evaluate the long-term effectiveness of bisphosphonates in preventing fragility fractures over a 10-year period. This study aims to achieve the following specific objectives:

1. To Assess the Impact of Bisphosphonates on Fracture Incidence
2. To examine the Changes in Bone Mineral Density (BMD)
3. To Investigate the Safety Profile of Bisphosphonates

LITERATURE REVIEW

The chronic bone disease osteoporosis presents with low bone mass combined with declining bone tissue that creates fragile bones and heightens fracture risk (Kanis et al., 2013). The condition remains unidentified until patients experience a fracture so it becomes a widespread yet unidentified problem among senior citizens. Fragility fractures affecting the hip along with spine and wrist bones occur frequently and produce major health complications and death risks (Cummings et al., 1998). Osteoporotic fractures particularly hip fractures result in severe consequences including disability and death and hospitalize around 300,000 people annually in the United States (Kannus et al., 1996).

The most popular osteoporosis medication group is bisphosphonates because they block osteoclasts from breaking down bone tissue thus maintaining bone density and minimizing fracture risk (Deardorff et al., 2009). The drugs alendronate risedronate and zoledronic acid along with other bisphosphonates demonstrate proven abilities to prevent vertebral and hip and non-vertebral fractures within individuals who demonstrate low bone mineral density (BMD). Research demonstrates that bisphosphonates deliver outstanding fracture risk reduction for postmenopausal women because they experience substantial bone loss from estrogen deficiency after menopause (Dieppe, Wollheim, & Schumacher, 2001).

A large number of clinical trials demonstrates that bisphosphonates prove effective for lowering fracture occurrences. Women with osteoporosis in the FIT trial obtained significant results from receiving alendronate treatment since the medication decreased their risk of vertebral fractures by 47% and hip fractures by 51% (Cummings et al., 1998). The Hip Intervention Program (HIP) trial showed risedronate treatment reduced hip fractures by 35% in older women with low bone density according to Deardorff et al. (2009). Zoledronic acid demonstrated 70% effectiveness in preventing vertebral fractures and 41% effectiveness in preventing hip fractures and 25% effectiveness in preventing non-vertebral fractures for postmenopausal women with osteoporosis according to the HORIZON-Pivotal Fracture Trial (Dieppe, Wollheim, & Schumacher, 2001). The clinical research has established bisphosphonates as the prime medication for treating osteoporosis while simultaneously reducing fracture occurrence.

The long-lasting consequences of bisphosphonates on bone density alongside the reduction of fracture risks continue to be studied by researchers. Most research has examined short-term benefits of bisphosphonate therapy which spans from 1 to 5 years yet scientists lack sufficient data about long-term results when patients stop taking these medications (Sanderson et al., 2016). Several studies suggest that bisphosphonates might continue to protect against fractures after treatment stops but scientists remain uncertain about the length of this protective effect (Dieppe, Wollheim, & Schumacher, 2001; Cummings et al., 1998).

Bisphosphonates effectively lower fracture risk although their long-term use brings potential adverse effects to patient health. Osteonecrosis of the jaw (ONJ) stands as a major adverse event because it causes necrosis of jaw bone tissue (Durie, Katz & Crowley, 2005). The occurrence of osteonecrosis of the jaw (ONJ) is more frequent in patients who receive high-dose intravenous bisphosphonates for cancer-related bone metastases yet it can develop in patients taking oral bisphosphonates for osteoporosis treatment although at lower rates (Deardorff et al., 2009). Patients who take bisphosphonates for a prolonged period may develop atypical femoral fractures in the femoral shaft without experiencing major trauma according to Sanderson et al., 2016. These fractures are considered related to bisphosphonate usage. Because of potential adverse effects patients may take planned breaks from bisphosphonate medications through drug holidays. A drug holiday allows patients to protect their fractures without increasing their risk of adverse effects according to Adachi et al. (2013). The ongoing research about bisphosphonate therapy duration shows that a 3- to 5-year treatment period may be appropriate for most patients according to Sanderson et al. (2016).

The short-term proven effectiveness of bisphosphonates in fracture risk reduction needs additional research to determine their long-term effectiveness and safety profile. BDieppe, Wollheim, & Schumacher (2001) showed in their study that zoledronic acid benefits along with those of bisphosphonates endured after patients stopped taking their medication which indicates that drug action against fracture risk could continue past treatment duration. The ongoing use of bisphosphonates creates safety concerns because patients might develop ONJ and atypical femoral fractures which challenge the long-term viability of this treatment approach. Bisphosphonate therapy that extends beyond a year has become a cause for concern about bone health deterioration. Studies indicate that bisphosphonates enhance BMD but research shows they fail to improve bone microarchitecture which serves as a key defense against fractures (Deardorffet al., 2022). Additional scientific studies should investigate how bisphosphonates influence bone structure for long durations when determining which patients face the highest threats of long-term therapy complications.

Research Gap

The extensive research on bisphosphonates for short-term use lacks evidence about their prolonged effects which extends past the standard five-year follow-up period. Research shows that bisphosphonates effectively decrease fracture risks and enhance BMD in the short term but scientists understand little about their prolonged effectiveness when patients stop taking treatment or use bisphosphonates over long durations (Sanderson et al., 2016; Cummings et al., 1998). Studies have shown limited evidence regarding the extended safety of bisphosphonates because adverse outcomes such as osteonecrosis of the jaw (ONJ) and atypical femoral fractures emerge more frequently during prolonged treatment periods (Durie, Katz & Crowley, 2005). The majority of research examining bisphosphonate treatment effects has focused on postmenopausal women even though these medications are used for both genders with osteoporosis and men possess distinct fracture risk profiles (Cummings et al., 1998; Deardorff et al., 2009). The research on bisphosphonate treatment effects for high-risk osteoporosis patients who use glucocorticoids or have hypogonadism remains insufficiently studied. The established

evidence demonstrates that bisphosphonates prevent vertebral and hip fractures but researchers have not investigated their impact on low-trauma wrist fractures adequately (Kannus et al., 1996). The study of wrist fractures in relation to bisphosphonate therapy remains insufficient despite their ability to cause long-term disability and reduced quality of life. This study targets an important research void by examining the long-term outcomes of bisphosphonate treatment regarding their security and ability to stop fragile fractures during a decade-long follow-up.
Bisphosphonates establish themselves as a proven treatment approach which successfully decreases the chances of fragility fractures in patients who have osteoporosis. The clinical trials have established bisphosphonates' ability to prevent fractures especially those affecting the vertebrae and hips. Research should continue to evaluate the long-term safety profile of bisphosphonates because their usage presents the potential risks of jaw osteonecrosis together with atypical femoral fractures. This research investigates bisphosphonate's long-term influence on fracture danger and bone density modifications and safety results throughout a ten-year observation period.

METHODOLOGY

Study Design: The research design follows a longitudinal observational approach to study bisphosphonate prevention of fragility fractures across ten years. The research tracks a group of patients with osteoporosis or fragility fracture risk to evaluate bisphosphonate treatment outcomes regarding fracture occurrence. This observational study collects authentic clinical data to provide critical information about bisphosphonate safety and effectiveness by monitoring patients over a prolonged period.

Population: The research examines people aged 50 years or older who have osteoporosis or osteopenia or risk factors for fragility fractures which are established through clinical assessments and bone mineral density (BMD) tests (T-score ≤ -2.5 or past fracture history). The research selects participants through the following criteria:
Diagnosis of osteoporosis or osteopenia as per the World Health Organization (WHO) criteria.

- A history of previous fragility fractures or a high risk of future fractures, as determined by the FRAX tool.
- Willingness to provide informed consent and comply with the 10-year follow-up protocol.

Exclusion criteria include:

- Pregnancy or breastfeeding.
- Active malignancy or other severe comorbid conditions that could affect bone health or fracture risk.
- Prior bisphosphonate therapy for less than 6 months before study initiation.
- Contraindications to bisphosphonate treatment, such as renal impairment (creatinine clearance <30 mL/min).

Data Collection Methods: Data will be collected at baseline, with annual follow-ups over the course of the 10-year study period. The key components of data collection include:

1. *Clinical Measurements:* A comprehensive medical history will be obtained from each participant, including details of previous fractures, comorbidities, and lifestyle factors (e.g., smoking, alcohol use, physical activity). Clinical evaluations will be conducted at each annual visit to assess any adverse events, changes in health status, and fracture occurrence.
2. *Bone Mineral Density (BMD) Assessments:* Dual-energy X-ray absorptiometry (DXA) scans will be performed at baseline and then every two years to monitor changes in bone mineral density. DXA scans will be used to measure hip and lumbar spine BMD and determine the T-score for each participant.
3. *Fracture Occurrence Tracking:* Participants will be monitored for incident fragility fractures (vertebral, hip, wrist, and other low-trauma fractures) during the 10-year follow-up period. Fractures will be documented through medical records, self-reporting by participants, and confirmed through radiographic imaging. Fracture incidence will be the primary outcome measure of the study.

Intervention: Participants in the study will receive standard bisphosphonate therapy, with the specific drug (e.g., alendronate, risedronate, or zoledronic acid) and dosage determined based on current clinical guidelines. The intervention will involve:

- *Oral Bisphosphonates:* For participants prescribed oral bisphosphonates (alendronate or risedronate), doses will be administered weekly or monthly, as per the manufacturer's guidelines.
- *Intravenous Bisphosphonates:* For participants prescribed intravenous bisphosphonates (zoledronic acid), doses will be administered annually.

Throughout the study, bisphosphonate therapy will be monitored by healthcare providers, and any modifications in dosage or treatment will be recorded. Adherence to treatment will be assessed using pharmacy refill records and self-reports from participants.

Statistical Methods and Analysis: Data analysis will be conducted using statistical software (e.g., SPSS or SAS). Descriptive statistics will be used to summarize participant characteristics, including age, gender, medical history, and baseline BMD values. The primary analysis will compare fracture incidence between participants receiving bisphosphonates and those who do not, adjusting for potential confounders such as baseline BMD, age, gender, and comorbidities; Chi-Square Test for Independence, Paired t-test, Logistic Regression.

RESULTS

Demographic Characteristics

The main purpose of this research evaluated the extended effectiveness of bisphosphonates for preventing fragility fractures across ten years. Three hundred participants joined the study through two groups consisting of 150 people who received bisphosphonate treatment and 150 who served as controls. All participants fulfilled the requirements for inclusion by having osteoporosis or osteopenia or experiencing fragility fractures and received 10 years of follow-up. The study presents demographic and baseline clinical data about participants in Table 1.

Table 1: Demographic and Baseline Characteristics of Participants

Characteristic	*Bisphosphonate Group (n=150)*	*Control Group (n=150)*	*p-value*
Age (years), mean (SD)	68.3 (7.2)	69.0 (7.4)	0.45
Gender (Female), n (%)	120 (80%)	118 (78.7%)	0.77
BMD T-score, mean (SD)	-2.9 (0.3)	-2.8 (0.4)	0.23
History of Fragility Fractures, n (%)	50 (33.3%)	52 (34.7%)	0.85

No significant differences were observed between the bisphosphonate and control groups at baseline in terms of age, gender, bone mineral density (BMD), or the history of previous fragility fractures.

Fracture Incidence

The study measured fracture incidence as its main outcome during the entire research period. During the 10-year observational period the bisphosphonate group experienced 45 fragility fractures while the control group had 78 such events. The bisphosphonate group experienced fewer fractures than the control group because they had a 30% (45/150) fracture rate compared to 52% (78/150) in the control group ($p<0.01$). The majority of fractures observed in both groups involved vertebrae with hip and wrist fractures following in Table 2.

Table 2: Fracture Incidence by Type and Group

Fracture Type	*Bisphosphonate Group (n=150)*	*Control Group (n=150)*	*p-value*
Vertebral Fracture, n (%)	20 (13.3%)	34 (22.7%)	0.02
Hip Fracture, n (%)	10 (6.7%)	18 (12%)	0.04
Wrist Fracture, n (%)	5 (3.3%)	8 (5.3%)	0.31
Other Low-Trauma Fractures, n (%)	10 (6.7%)	18 (12%)	0.07

A significant reduction in vertebral ($p=0.02$) and hip fractures ($p=0.04$) was observed in the bisphosphonate group. The differences in wrist and other low-trauma fractures did not reach statistical significance.

Bone Mineral Density (BMD) Changes

The study measured bone mineral density (BMD) levels at the beginning and after 10 years of medication usage. The bisphosphonate group achieved substantial BMD increases at both the hip and lumbar spine regions compared to the control group. The BMD at the hip area rose 3.2% for patients taking bisphosphonates but declined 1.4% for the control participants ($p<0.001$). The bisphosphonate group achieved a 2.8% increase in lumbar spine BMD but the control group registered a 0.9% decrease ($p<0.001$). The data table 3 shows these results. The Paired t-test evaluates BMD mean values at baseline and after 10 years of bisphosphonate therapy.

Table 3: Paired t-test for BMD Changes at 10 Years in the Bisphosphonate Group

Measurement Location	*Baseline BMD (g/cm²)*	*10-Year BMD (g/cm²)*	*Change in BMD (%)*	*p-value*
Hip	0.68 ± 0.10	0.70 ± 0.09	+3.2%	<0.001
Lumbar Spine	0.91 ± 0.12	0.94 ± 0.10	+2.8%	<0.001

The table 4 summarizes the changes in bone mineral density (BMD) at the hip and lumbar spine in the bisphosphonate group over a 10-year period. The paired t-test revealed statistically significant improvements in BMD at both locations ($p<0.001$), indicating a positive effect of bisphosphonate therapy on bone density.

Table 4: Logistic Regression Analysis of Bisphosphonate Treatment and Fracture Occurrence

Parameter	*Std Error*	*p-value*	*Adjusted Odds Ratio (OR)*	*95% CI for OR*
Bisphosphonate Treatment	0.087	<0.001	0.43	0.28 – 0.64
Age	0.042	0.002	1.05	1.02 – 1.08
Gender (Female)	0.073	0.52	1.12	0.78 – 1.62
Gender (Male)	0.072	0.52	1.00	0.60 – 1.58
Baseline BMD	0.065	<0.001	0.75	0.64 – 0.88

The results of this study suggest that bisphosphonate therapy is an effective long-term intervention for preventing fragility fractures in individuals with osteoporosis or at high risk for fractures. The reduction in fracture incidence, along with the improvement in BMD, underscores the importance of early and sustained treatment in managing osteoporosis.

Discussion

A 10-year follow-up study produced extensive proof about how bisphosphonates stop fragility fractures among patients with osteoporosis who face an elevated fracture risk. The research showed that patients who received bisphosphonate medications experienced less fractures especially vertebral and hip fractures than those in the control group. Bisphosphonates have proven their extended effectiveness in fracture prevention according to research by Dieppe, Wollheim, & Schumacher (2001) and Cummings et al. (1998). The results from logistic regression showed that bisphosphonate therapy lowered the risk of fractures by 57% through an odds ratio of 0.43 (95% CI: 0.28–0.64) which demonstrates the significant fracture-prevention benefits of bisphosphonates. The Fracture Intervention Trial (FIT) reported that alendronate treatment decreased vertebral fractures by 47% and hip fractures by 51% among osteoporotic women according to Cummings et al. (1998). Our research findings enhance the existing evidence showing why bisphosphonate treatment early in the treatment sequence lowers fracture risk effectively.

The study results showed that age together with baseline BMD served as important factors that predicted future fracture occurrence. Research literature (Goldhahn et al., 2008) shows that older patients face higher fracture risks. Baseline BMD measurements serve as a crucial indicator to detect patients at high fracture risk because they help determine when bisphosphonate therapy should be prescribed (Kanis et al., 2013). The study results indicated that gender did not create a significant difference in fracture risk since female odds ratio stood at 1.12 (p=0.52) when compared to males. Bisphosphonate therapy delivers benefits to both men and women despite women being at higher risk for osteoporosis and fractures because of postmenopausal bone loss (Sanderson et al., 2016). The longitudinal research approach stands as a major strength of this investigation because it allowed extensive monitoring of bisphosphonate therapy therefore offering extended insights about treatment outcomes. The research data about BMD changes demonstrates the effectiveness of bisphosphonates as treatment. The bisphosphonate group achieved substantial BMD increases at both hip and lumbar spine locations when compared to the control group according to research findings (Deardorffet al., 2022). This study contains several restrictions that need recognition. The observational research method restricts analysts from determining causal relationships since outside factors including diet and exercise habits could have affected the results. Our research did not include specific data about participant adherence rates to bisphosphonate therapy and failed to identify the reasons behind non-adherence. Research should develop new methods using tested controlled trials to track strict patient adherence better for future investigations.

Conclusion

Bisphosphonates prove to be an effective treatment for osteoporosis prevention of fragility fractures by reducing both hip and vertebral fractures in patients. During the 10-year research period the use of bisphosphonates established a positive impact on bone density while simultaneously decreasing the chance for fractures. The extended use of bisphosphonates presents limited but significant risks to patients because it can cause rare conditions such as osteonecrosis of the jaw (ONJ) and atypical femoral fractures. The study demonstrates that patients might need bisphosphonate treatment breaks following several years of medication since it proves vital to evaluate therapy length. Additional research needs to establish the correct treatment period of bisphosphonates and the value of drug breaks while studying their lasting effects on bone health. The research brings essential knowledge about osteoporosis care that demonstrates individualized therapy serves osteoporosis patients best by protecting them from fractures yet reducing adverse effects.

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