Reumatologia 2026; 64
DOI: https://doi.org/10.5114/reum/224406

# Diagnosis and treatment of osteoporosis: 2026 recommendations of the Polish Society for Rheumatology

**Piotr Leszczyński[1,2,#], Cezary Iwaszkiewicz[2,#] ✉, Zbigniew Michał Żuber[3], Brygida Kwiatkowska[4], Bogdan Piotr Batko[5], Katarzyna Krystyna Pawlak-Buś[1,2]**

[1]Department of Internal Medicine and Metabolic Disorders, Poznan University of Medical Sciences, Poland
[2]Department of Rheumatology, Systemic Connective Tissue Diseases and Immunotherapy of Rheumatic Diseases, Jozef Strus Hospital in Poznan, Poland
[3]Department of Paediatrics, Faculty of Medicine and Health Sciences, Andrzej Frycz Modrzewski Krakow University, Poland
[4]Early Arthritis Clinic, National Institute of Geriatrics, Rheumatology and Rehabilitation, Warsaw, Poland
[5]Department of Rheumatology and Immunology, Faculty of Medicine and Health Sciences, Andrzej Frycz Modrzewski Krakow University, Poland
[#]*These authors contributed equally to this work.*

Abstract
This publication presents the official recommendations of the Polish Society for Rheumatology for the diagnosis and treatment of osteoporosis. A panel of 6 experienced rheumatologists developed the document using an evidence-informed consensus process incorporating current evidence, clinical experience and the Polish healthcare context. Unanimous agreement was reached on all recommendations. The diagnostic section outlines the diagnostic criteria for osteoporosis in different patient groups and defines, for the first time, the role of radiofrequency echographic multi-spectrometry in clinical practice. The therapeutic section provides guidance on the optimal use of anti-osteoporotic drugs, including sequential therapy, and highlights the benefits of initiating treatment with an anabolic agent in patients at very high fracture risk. The document also addresses prevention of glucocorticoid-induced osteoporosis, osteoporosis in premenopausal women, and diagnosis and treatment in the paediatric population. These recommendations are intended to support early diagnosis and effective management of osteoporosis in Poland.

**Key words:** osteoporosis, bone density, osteoporotic fractures, clinical practice guideline.

## Introduction

Demographic changes across Europe are leading to an increase in the incidence of osteoporosis, and the medical and socio-economic consequences of osteoporotic fractures are substantial [1]. This underlines the importance of measures supporting the early detection and effective treatment of osteoporosis. These recommendations constitute the official position of the Polish Society for Rheumatology (*Polskie Towarzystwo Reumatologiczne* – PTR) and update its 2015 position statement, revised in 2017 [2]. The authors did not intend to impose restrictions on clinical practice but rather to define the current standard of care. Adherence to these recommendations is not mandatory, and individual diagnostic and therapeutic decisions remain the responsibility of the treating physician. Such decisions require consideration of a broader context, including organisational, ethical and legal aspects, as well as patients' clinical condition, social circumstances, preferences and expectations. These recommendations are intended for all physicians involved in the care of patients with diagnosed or suspected osteoporosis.

## Methods

These recommendations were developed as an evidence-informed consensus statement. The consensus panel comprised 6 rheumatologists who were PTR experts: 5 with many years of clinical experience in the dia-

Address for correspondence
Cezary Iwaszkiewicz, Department of Rheumatology, Systemic Connective Tissue Diseases and Immunotherapy of Rheumatic Diseases, Jozef Strus Hospital in Poznan, 3 Szwajcarska St., 61-285 Poznan, Poland, e-mail: cezary.iwaszkiewicz@gmail.com
**Submitted:** 05.05.2026; **Accepted:** 10.06.2026; **Published online:** 17.06.2026

gnosis and treatment of osteoporosis in adults, and 1 paediatric rheumatologist with many years of clinical experience in the diagnosis and treatment of osteoporosis in children and adolescents. The experts were selected on the basis of their clinical experience and areas of expertise. The authors represented 4 rheumatology centres in Poland. The first stage involved identifying the clinical questions, which then informed the titles and structure of the subsequent sections of the recommendations. This was followed by a review of the English-language literature published up to the end of 2025, identified through searches of MEDLINE (via PubMed) and the Cochrane Library. This process was repeated separately for each section. As the authors aimed to develop a practical clinical position statement rather than to conduct reimbursement analyses, formal evidence-grading systems were not applied. Each source was assessed individually for methodological quality, currency and clinical relevance. When formulating the recommendations, priority was given to evidence from meta-analyses, systematic reviews and randomised clinical trials. Recommendations from other scientific societies, particularly international ones, were also reviewed, taking into account their implications for clinical practice. At the final stage, following repeated discussion and revision of the document, unanimous agreement was reached on all recommendations. This methodology ensured that current evidence, the authors' clinical experience, and the context of the Polish healthcare system were all taken into account.

## Diagnosis of osteoporosis and assessment of fracture risk

### Definition of osteoporosis

Osteoporosis is a systemic skeletal disease characterised by low bone mass and microarchitectural deterioration of bone tissue, resulting in increased bone fragility and fracture risk [3].

### Role of bone densitometry in the diagnosis and monitoring of osteoporosis

Bone mineral density (BMD) is one of the strongest predictors of fracture risk, underpinning the role of bone densitometry in the diagnosis and monitoring of osteoporosis [4]. Bone densitometry is recommended in any clinical situation where the result could influence clinical management and thereby reduce fracture risk. Examples include women aged ≥ 65 years, men aged ≥ 70 years, adults with risk factors for low bone mass or bone loss (e.g. prior low-energy fracture, low body weight, diseases, or medications), and all patients receiving or being considered for anti-osteoporosis treatment [5].

### Methods of bone densitometry

The gold standard for bone densitometry is dual-energy X-ray absorptiometry (DXA) [5].

A newer bone densitometry method is radiofrequency echographic multi-spectrometry (REMS). This method enables assessment of BMD at the hip and lumbar spine through automated analysis of ultrasound echoes backscattered from bone. As with DXA, REMS results are expressed in g/cm$^2$ and interpreted using the standard densitometric parameters (*T*-score and *Z*-score), and hip *T*-score values are calculated using the same NHANES III (National Health and Nutrition Examination Survey III) reference database [6]. The REMS device was cleared by the US Food and Drug Administration (FDA) in 2018 [7]. According to FDA documents, BMD measurements obtained by DXA and REMS show high correlation ($r = 0.94$ at the spine and $r = 0.93$ at the hip) and comparable precision, supporting the use of REMS in the diagnosis of osteoporosis, monitoring of BMD changes, and assessment of fracture risk [7, 8]. In 2019, the usefulness of REMS was favourably evaluated by a working group of the European Society for Clinical and Economic Aspects of Osteoporosis, Osteoarthritis and Musculoskeletal Diseases (ESCEO). The ESCEO paper presented numerous arguments in support of introducing REMS into clinical practice [9]. Also in 2019, an analysis of the clinical significance of REMS densitometry by members of the PTR Metabolic Bone Diseases Section was published [6]. Finally, in 2020, the results of a prospective study were published confirming the ability of REMS to predict low-energy fractures. The study followed 1,370 women aged 30–90 years over a 5-year period [10]. The REMS method allows reliable assessment of hip and lumbar spine BMD in women and men aged 30–90 years [8, 11]. It also has several unique features, including the portability of the equipment, the absence of ionising radiation, and the automatic exclusion of measurements affected by artefacts or technical errors [6, 12–16]. These features of REMS may improve access to bone densitometry and increase the detection of osteoporosis in Poland.

In view of the available evidence and the Polish healthcare context, REMS may be used in the diagnosis and monitoring of osteoporosis as an alternative to DXA in women and men aged 30–90 years. Given their different physical principles and the practical implications of these differences, the 2 densitometric methods may be regarded as complementary.

### Densitometric criterion for the diagnosis of osteoporosis

In postmenopausal women and in men aged ≥ 50 years, osteoporosis may be diagnosed on the basis of the bone

densitometry result alone. In this population, the densitometric criterion for the diagnosis of osteoporosis is a *T*-score of ≤ –2.5 at the lumbar spine or femoral neck or total hip. This criterion may also be applied to women during the menopausal transition [5]. The menopausal transition is the period preceding menopause in which menstrual cycles become irregular and there is a persistent difference of 7 days or more in the length of consecutive cycles [17].

In women before menopause (or before the menopausal transition) and in men under 50 years of age, the primary parameter for the interpretation of BMD is the *Z*-score. A *Z*-score of ≤ –2.0 is interpreted as "BMD below the expected range for age and sex", whereas a *Z*-score of > –2.0 is interpreted as "BMD within the expected range for age and sex". In women before menopause (or before the menopausal transition) and in men under 50 years of age, osteoporosis cannot be diagnosed on the basis of the bone densitometry result alone, and the presence of an osteoporotic fracture is required. Therefore, there is no diagnostic criterion for osteoporosis based on the *Z*-score [5].

In adults, BMD measurement at both central sites, namely the hip and the lumbar spine, is recommended. Measurement of BMD at the 33% radius (also referred to as the one-third radius) is technically possible only with DXA and is used mainly in patients with hyperparathyroidism. A second indication for measurement at the 33% radius is the inability to obtain a reliable assessment of BMD at the hip and/or spine [5]. Examples of such situations include osteophytes, vertebral fractures, kidney stones, soft tissue calcifications, postoperative artefacts, and marked obesity [18–20]. Adapting this recommendation to current technical capabilities, measurement of BMD at the 33% radius is fully justified when a reliable bone densitometry result at the hip or lumbar spine cannot be obtained with either DXA or REMS.

In lumbar spine densitometry, vertebrae L1–L4 are routinely assessed in the posteroanterior (PA) projection. Only those vertebrae whose assessment is unreliable because of structural changes or other artefacts should be excluded from analysis, and BMD must be measured in at least 2 vertebrae for the result to be of diagnostic value [5].

## Low bone mass

The term "osteopenia" has been replaced by "low bone mass" and should not be used. Low bone mass is defined by a *T*-score lower than –1.0 and higher than –2.5. This applies only to postmenopausal women and to men over 50 years of age. Low bone mass is not considered a disease, but an epidemiological category [4, 5].

## Discrepancies between densitometry results obtained at different regions of interest or by different densitometry methods

If densitometry results obtained at different regions of interest (ROIs) – i.e. vertebrae L1–L4, the femoral neck, or the total hip – classify the patient into different diagnostic categories, clinical decisions should be based on the lower result. Similarly, if DXA and REMS densitometry results are discrepant, clinical decisions should be based on the lower result, and the method used to obtain it should be preferred for follow-up measurements. These recommendations are based on the observation that artefacts affecting densitometry results usually lead to overestimation of BMD. Artefacts leading to underestimation of BMD are very rare and, in clinical practice, are limited to the consequences of surgical procedures [18–20]. In addition, although osteoporosis is a systemic skeletal disease, the dynamics of BMD changes in different skeletal regions may differ substantially, leading to discrepancies between densitometry results obtained at individual ROIs at a given time point [21, 22].

## Quality and comparability of bone densitometry results

Bone densitometry, regardless of the method used, should be performed in certified centres. The Polish Society for Rheumatology organises DXA and REMS courses, and participants who pass the examination receive a certificate valid for a limited period.

Bone densitometry by DXA should be performed and interpreted in accordance with the current Official Positions of the International Society for Clinical Densitometry (ISCD). Whenever possible, the ISCD Official Positions should also be taken into account in the performance and interpretation of REMS densitometry. This view is based on the fundamental similarities between the 2 methods and on the lack of recommendations specific to REMS densitometry.

## Follow-up bone mineral density testing

Serial BMD measurements allow monitoring of disease course and response to treatment. Response to treatment may be reflected in increased or stable BMD values. A significant decrease in BMD during osteoporosis treatment requires assessment of patient adherence, identification of new risk factors, and evaluation of treatment efficacy. The frequency of follow-up BMD testing should be tailored to the individual clinical situation. Testing should be performed when the result could influence treatment decisions. Follow-up BMD testing is recommended 12 months after the initiation or modification

of osteoporosis treatment, with progressively longer intervals thereafter, usually up to 2 years, if the therapeutic effect is maintained over the long term [23]. Conditions associated with accelerated BMD loss, such as treatment with glucocorticosteroids (GCs), may justify more frequent BMD testing, usually every 6 months [24]. The follow-up DXA report should include the least significant change (LSC), which allows comparison of serial BMD measurements. For results to be comparable, BMD measurements must be performed on the same device [5].

## Clinical criterion for the diagnosis of osteoporosis

In patients with a documented osteoporotic fracture, osteoporosis may be diagnosed and treatment initiated without meeting the densitometric criterion. In such cases, densitometry has no diagnostic role, but it may be useful for monitoring changes in BMD and response to treatment. Most low-energy fractures occur in patients with BMD > –2.5, highlighting the importance of bone microarchitecture [25–27].

A low-energy fracture results from a force that would not cause a fracture in healthy bone, such as a fall from standing height or a spontaneous fracture [28]. An osteoporotic fracture is a low-energy fracture that cannot be explained by a cause other than osteoporosis. This means that the diagnosis of osteoporosis on the basis of the clinical criterion requires exclusion of other possible causes of low-energy fractures. Low-energy fractures unrelated to osteoporosis include pathological fractures resulting from local bone lesions, such as malignancy or infection [29]. The most common sites of osteoporotic fracture are the spine, hip, proximal humerus, and distal radius. These are referred to as major osteoporotic fractures. It should be emphasised, however, that osteoporosis, as a systemic skeletal disease, may cause fractures at various sites, and the decision to classify a particular fracture as osteoporotic should be made by the physician on the basis of a comprehensive clinical assessment [4, 30–32]. The diagnostic criteria for osteoporosis are summarised in Figure 1.

## Osteoporosis in rheumatic diseases

In patients with rheumatic diseases, the general principles for the diagnosis and monitoring of osteoporosis apply. Fracture risk assessment should take into account additional individual factors related to the pathophysiology, clinical manifestations, disease activity, and

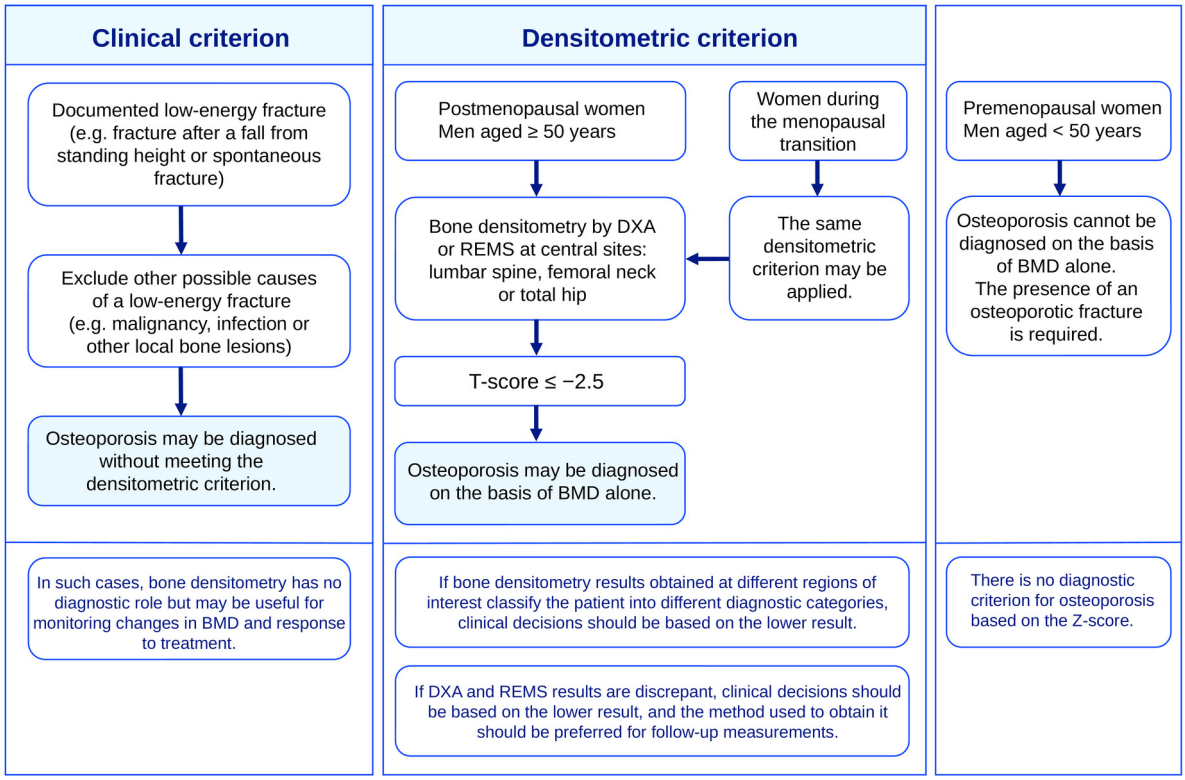


**Fig. 1.** Diagnostic criteria for osteoporosis.

*BMD – bone mineral density, DXA – dual-energy X-ray absorptiometry, REMS – radiofrequency echographic multi-spectrometry.*

treatment of the underlying disease. Chronic inflammatory diseases and GC therapy may increase fracture risk independently of classical risk factors, including BMD. To date, no tool has been developed for reliable fracture risk assessment in rheumatic diseases, and the risk calculated using standard algorithms may be underestimated [33–39].

### Vertebral fracture assessment by dual-energy X-ray absorptiometry

Widespread use of vertebral fracture assessment (VFA) is recommended for the detection and monitoring of vertebral fractures. This technique enables automated identification of fractures of the vertebral bodies from T4 to L4 using a DXA densitometer. Fracture severity is assessed using the Genant visual semi-quantitative method. The VFA examination may complement or provide an alternative to standard radiological imaging (plain radiography or computed tomography) and should be performed in conjunction with DXA densitometry in patients at high risk of fracture [5].

### Fracture Risk Assessment Tool calculator

The Fracture Risk Assessment Tool (FRAX) calculator is an algorithm for estimating the 10-year probability of a major osteoporotic fracture and hip fracture on the basis of clinical fracture risk factors and demographic data. Femoral neck BMD is an optional input that enhances fracture risk prediction [4]. The FRAX calculator was developed for patients aged 40–90 years who have not received anti-osteoporosis treatment. It is a simple and accessible tool, particularly useful in primary care. The FRAX algorithm does not take lumbar spine BMD into account, nor does it capture the severity of individual fracture risk factors, including the number of prior fractures, the exact dose and duration of GC therapy, or the number of cigarettes smoked. It also does not take into account certain important fracture risk factors, such as type 2 diabetes, chronic kidney disease, or risk of falls [40–42].

In some countries, clinical decisions are based on fracture probability calculated using FRAX, and intervention thresholds reflect the financial capacity of the country's healthcare system. For example, treatment is recommended when the probability of a major osteoporotic fracture is ≥ 20% or the probability of hip fracture is ≥ 3%. These thresholds are derived from cost-effectiveness analyses conducted in the USA, and their extrapolation to other populations is controversial. Equally controversial is the arbitrary setting of intervention thresholds without a comprehensive epidemiological and economic assessment in the country in question. In a more appropriate approach, the FRAX intervention threshold increases with age, but the authors consider this too difficult to implement in the Polish healthcare system at present [4].

The FRAX algorithm with BMD is a valuable adjunctive tool, but because of its important limitations it should not be the sole or definitive basis for clinical decisions.

### Very high fracture risk

With the availability of anabolic agents and the need to individualise osteoporosis treatment, a category of very high fracture risk has been introduced. Examples of criteria used to identify patients at very high fracture risk include a recent osteoporotic fracture (within the last 2 years), a history of at least 2 osteoporotic fractures (including vertebral fractures), a prior osteoporotic fracture at a specific site (spine, hip or pelvis), very low BMD (*T*-score ≤ –3.0 or ≤ –3.5), and a low-energy fracture during osteoporosis treatment or during GC therapy. Various combinations of risk factors have also been proposed, including *T*-score with an osteoporotic fracture, *T*-score with clinical fracture risk factors, and, in some countries, the FRAX score [43–45]. The diversity of criteria reflects the absence of a uniform definition of very high fracture risk. In Poland, fracture risk should be assessed individually by the physician on the basis of a comprehensive clinical evaluation, including the densitometry result.

### Trabecular bone score

Trabecular bone score (TBS) is an adjunctive tool for the quantitative assessment of bone microarchitecture derived from lumbar-spine DXA images. When interpreted in conjunction with BMD and other fracture risk factors, TBS may support clinical decision-making [46, 47].

### Bone turnover markers

In clinical studies, 2 laboratory bone turnover markers have been designated as reference markers: serum procollagen type I *N*-terminal propeptide (s-PINP) as a marker of bone formation and serum *C*-terminal telopeptide of type I collagen (s-CTX) as a marker of bone resorption [48]. However, commercially available assays for s-PINP and s-CTX differ substantially in analytical method, measuring range, repeatability and reproducibility, which in practice precludes comparability of results. Interpretation of these results should also take into account age, sex, ethnicity, physical activity, comorbidities, medications, the circadian rhythm of the markers, and sample storage conditions, all of which would require extensive reference data [48–51].

In view of the need to standardise or harmonise laboratory assays, as well as to establish reference intervals

and decision thresholds for different clinical settings, the routine use of bone turnover markers is not currently recommended.

**Key points:**

- In postmenopausal women and in men aged ≥ 50 years, osteoporosis may be diagnosed on the basis of the bone densitometry result alone. The diagnostic criterion is a *T*-score of ≤ –2.5 at the lumbar spine, femoral neck or total hip. This criterion may also be applied to women during the menopausal transition.
- In women before menopause (or before the menopausal transition) and in men under 50 years of age, osteoporosis cannot be diagnosed on the basis of the bone densitometry result alone, and the presence of an osteoporotic fracture is required.
- An osteoporotic fracture is a low-energy fracture that cannot be explained by a cause other than osteoporosis. In each case, a pathological fracture resulting from local bone lesions (e.g. malignancy or infection) should be excluded.
- In patients with a documented osteoporotic fracture, osteoporosis may be diagnosed without meeting the densitometric criterion. In such cases, densitometry has no diagnostic role but may be useful for monitoring treatment.
- The gold standard for bone densitometry is DXA.
- In view of the available evidence and the Polish context, REMS densitometry may be used in the diagnosis and monitoring of osteoporosis as an alternative to DXA in women and men aged 30–90 years.
- Bone densitometry by DXA should be performed and interpreted in accordance with the current ISCD Official Positions. Whenever possible, the ISCD Official Positions should also be taken into account in the performance and interpretation of REMS densitometry.
- In adults, measurement of BMD at both central sites (the hip and the lumbar spine) is recommended.
- If DXA and REMS densitometry results are discrepant, clinical decisions should be based on the lower result, and the method used to obtain it should be preferred for follow-up measurements.
- If densitometry results obtained at different ROIs classify the patient into different diagnostic categories, clinical decisions should be based on the lower result.
- Follow-up bone densitometry is recommended 12 months after initiation or modification of osteoporosis treatment, with progressively longer intervals thereafter if a sustained therapeutic effect is maintained. Conditions associated with accelerated BMD loss, such as GC therapy, may justify more frequent densitometry.
- Widespread use of VFA is recommended for the detection and monitoring of vertebral fractures. In patients at high fracture risk, VFA should be performed in conjunction with DXA densitometry.
- Fracture risk assessment in rheumatic diseases should take into account not only classical risk factors but also additional individual factors related to the pathophysiology, clinical manifestations, disease activity and treatment of the underlying disease.
- The FRAX algorithm with BMD is a valuable adjunctive tool. However, because of its important limitations, it should not be the sole or definitive basis for clinical decisions.

## Treatment of osteoporosis

### Treatment goal

The primary goal of osteoporosis treatment is the prevention of fractures. The occurrence of a low-energy fracture during treatment does not necessarily indicate treatment failure, and each case requires detailed clinical assessment. History taking should include evaluation of patient adherence, new comorbidities or medications, and other factors that may increase fracture risk. Follow-up bone densitometry should be considered in all cases [52]. If osteoporosis treatment has been ongoing for less than 12 months, it should not be considered ineffective [53].

### Prevention of falls

In the treatment and education of patients with osteoporosis, efforts should be made to eliminate risk factors for falls, such as the effects of diseases or medications on balance and reaction time, uncorrected visual or hearing impairment, inappropriate footwear, and environmental hazards (slippery floors, physical obstacles, lack of handrails, insufficient lighting, etc.) [54–57].

### Exercise

Regular, well-designed exercise stimulates bone formation and is an integral part of osteoporosis treatment. Weight-bearing aerobic exercises and resistance training are the most effective. By improving muscle strength, coordination and balance, physical activity plays a key role in the prevention of falls. Exercises for patients with osteoporosis should be varied and individually tailored [56–61]. In Poland, physiotherapists are responsible for selecting exercises and for providing patients with instructions on how to perform the exercises correctly.

### Diet

In patients with osteoporosis or at high risk of fracture, the diet should provide an adequate intake of protein

and calcium. A healthy dietary pattern is recommended, including vegetables, fruit, whole grains, poultry, fish, nuts, legumes and low-fat dairy products, while limiting processed foods [62–65].

## Vitamin D and calcium

Vitamin D plays an important role in the regulation of calcium-phosphate homeostasis and bone remodelling. In patients with osteoporosis, vitamin D and calcium deficiencies are risk factors for accelerated BMD loss. In addition, vitamin D affects skeletal muscle metabolism and regeneration [66]. In a meta-analysis including more than 61,000 individuals, daily supplementation with ≥ 700 IU of vitamin D significantly reduced the risk of falls, and this effect was greater when calcium was co-administered [67].

It is estimated that vitamin D deficiency affects two-thirds of the Polish population [68]. Calcifediol (25(OH)D) is the best marker of vitamin D status [66]. The optimal serum 25(OH)D concentration is 30–50 ng/ml, and values below 20 ng/ml indicate vitamin D deficiency [69].

Oral cholecalciferol (vitamin $D_3$) is recommended for the prevention and treatment of vitamin D deficiency [70]. In adults, the vitamin D supplementation dose is 800–2,000 IU daily. Higher doses of 2,000–4,000 IU daily are recommended in obesity, malabsorption syndromes, or in people with dark skin [69]. This wide dose range reflects individual variation in response to vitamin D supplementation, although for most healthy individuals a daily dose of 1,000 IU is sufficient [71].

For more rapid correction of vitamin D deficiency, loading doses of 6,000–10,000 IU daily may be used during the first 4–12 weeks, followed by supplementation at the recommended doses [69]. Where very rapid correction of vitamin D deficiency is required, higher loading doses may be considered, up to 60,000 IU daily for 7 consecutive days, but this requires specialist supervision and monitoring of serum calcium concentrations [72].

Intermittent dosing of vitamin D, for example once weekly or once monthly, is as safe and effective as daily dosing. This applies both to supplementation and to loading doses [69]. When intermittent dosing is used, it is recommended that the daily dose should not exceed 60,000 IU, which is considered safe [72, 73].

To monitor treatment effectiveness, serum 25(OH)D may be remeasured 6–12 weeks after starting supplementation [69].

In patients with osteoporosis, the target 25(OH)D concentration should be achieved promptly before starting antiresorptive or anabolic therapy. In this population, vitamin D is recommended in combination with calcium supplementation, particularly when dietary calcium intake is insufficient, that is, below approximately 1,000 mg daily [4, 74, 75]. In most clinical trials, anti-osteoporosis treatment was used in combination with calcium supplementation [69].

The use of vitamin K in combination with vitamin D is not recommended in the treatment of osteoporosis. The available data do not demonstrate clear clinical benefit of vitamin K supplementation in either the treatment or prevention of osteoporosis [76].

**Key points:**

- In patients with osteoporosis, an optimal serum 25(OH)D concentration of 30–50 ng/ml should be ensured.
- In the treatment of osteoporosis, vitamin D is recommended in combination with calcium supplementation.
- Anti-osteoporosis treatment should be preceded by rapid correction of vitamin D and calcium deficiencies.
- The use of loading and/or intermittent doses of cholecalciferol is safe and may be helpful in achieving optimal vitamin D status.

## Pharmacotherapy

Anti-osteoporosis drugs exert antiresorptive, anabolic (bone-forming), or dual (anabolic-antiresorptive) effects. The main pharmacological treatment options are summarised in Table I.

## Sequential and combination therapy

Sequential therapy is the use of different anti-osteoporosis drugs in sequence to optimise the efficacy and safety of long-term treatment. The use of antiresorptive drugs after treatment with agents whose therapeutic effects are rapidly reversible upon discontinuation (e.g. denosumab, romosozumab or teriparatide) prevents predictable BMD loss and is referred to as consolidation therapy. Initiating sequential therapy with an osteoanabolic agent, followed by consolidation with an antiresorptive drug, leads to the greatest BMD gains and the greatest and most sustained reduction in fracture risk. Conversely, prior antiresorptive treatment reduces the efficacy of anabolic agents. Consistent with these data, in patients at very high fracture risk, sequential therapy should be initiated with an osteoanabolic agent, followed by consolidation with an antiresorptive drug [43–45].

Conclusive evidence on the safety and efficacy of combination therapy with different anti-osteoporosis drugs is still lacking [77]. Therefore, combination therapy is not currently recommended – its use should be limited to rare, well-justified cases, based on the available evidence, and reserved for specialist centres.

**Table I.** Pharmacological treatment of osteoporosis

| Drug | Dose | Mechanism of action | Indications | Fracture-risk reduction† | | | Treatment duration | Consolidation therapy |
|---|---|---|---|---|---|---|---|---|
| | | | | Vertebral | Non-vertebral | Hip | | |
| Alendronate | 70 mg orally once weekly | Antiresorptive | – Treatment of osteoporosis in women and men, including GIOP<br>– Prevention of osteoporosis in patients at increased fracture risk, including prevention of GIOP | Yes | Yes | Yes | Data on the safety and efficacy of oral bisphosphonate treatment for > 10 years or intravenous treatment for > 6 years are limited* | N/A |
| Risedronate | 35 mg orally once weekly | Antiresorptive | | Yes | Yes | Yes | | N/A |
| Zoledronate | 5 mg intravenously every 12 months | Antiresorptive | | Yes | Yes | Yes | | N/A |
| Ibandronate | 150 mg orally once monthly or 3 mg intravenously every 3 months | Antiresorptive | – Treatment of osteoporosis in postmenopausal women | Yes | No‡ | No | | N/A |
| Denosumab | 60 mg subcutaneously every 6 months | Antiresorptive | – Treatment of osteoporosis in postmenopausal women at increased fracture risk and in men at increased fracture risk<br>– Treatment and prevention of GIOP in adults at increased fracture risk | Yes | Yes | Yes | Data on the safety and efficacy of treatment for > 10 years are limited* | – Bisphosphonate treatment should be initiated 6 months after the last denosumab injection and continued for at least 1 year<br>– Zoledronate or alendronate is recommended |
| Romosozumab | 210 mg subcutaneously once monthly as 2 injections of 105 mg each | Anabolic-antiresorptive | – Treatment of severe osteoporosis in postmenopausal women at high fracture risk<br>– Recommended as initial osteoporosis treatment in postmenopausal women at very high fracture risk | Yes | Yes | Yes | Treatment lasts 12 months | – Antiresorptive treatment should be initiated 1 month after the last dose of romosozumab and continued for at least 1 year<br>– Most evidence is available for denosumab, alendronate and zoledronate |
| Teriparatide | 20 µg subcutaneously daily | Anabolic | – Treatment of osteoporosis in postmenopausal women at increased fracture risk and in men at increased fracture risk<br>– Treatment of GIOP in women and men at increased fracture risk<br>– Recommended as initial osteoporosis treatment in patients at very high fracture risk | Yes | Yes | No§ | Maximum total duration of treatment is 24 months | – Antiresorptive treatment should be initiated immediately after stopping teriparatide and continued for at least 1 year<br>– The efficacy of bisphosphonates and denosumab has been demonstrated |
| Raloxifene | 60 mg orally once daily | Antiresorptive | – Treatment and prevention of osteoporosis in postmenopausal women when all other drugs are contraindicated | Yes | No | No | Data on the safety and efficacy of treatment are limited to 8 years | N/A |

**Decisions about longer continuation of therapy should be made on an individual basis and jointly with patients.*
*†Fracture-risk reduction demonstrated for vertebral, non-vertebral or hip fractures in postmenopausal women treated for osteoporosis.*
*‡A reduction of non-vertebral fracture risk with ibandronate was demonstrated only in a post hoc analysis of a subgroup of women with a femoral neck T-score < –3.0.*
*§The effect on hip fracture risk could not be reliably assessed in individual clinical trials because of the low number of observed fractures; however, a meta-analysis of 23 randomised clinical trials suggests a significant reduction in this risk.*
*GIOP – glucocorticoid-induced osteoporosis, N/A – not applicable.*

## Bisphosphonates

Bisphosphonates are synthetic analogues of pyrophosphate that inhibit osteoclast activity and promote osteoclast apoptosis, thereby reducing bone resorption [78]. A unique feature of bisphosphonates is their prolonged skeletal retention, allowing the antiresorptive effect to persist long after treatment has been stopped. The half-life of bisphosphonates in bone may exceed 10 years [79].

Alendronate, risedronate and zoledronate significantly reduce the risk of vertebral and non-vertebral fractures, including hip fractures [80–83]. By contrast, ibandronate reduces vertebral fracture risk only, which limits its usefulness. A reduction of non-vertebral fracture risk with ibandronate has been demonstrated only in a post hoc analysis of a subgroup of women with a femoral neck *T*-score < –3.0 [84].

Bisphosphonates are recommended for the treatment of osteoporosis in women and men, including glucocorticosteroid-induced osteoporosis (GIOP). Evidence allowing comparison of the anti-fracture efficacy of different bisphosphonates is limited [80, 81]. Given their effect on hip fracture risk, alendronate, risedronate and zoledronate may be regarded as first-line options, whereas ibandronate may be regarded as a second-line option. It should also be noted that ibandronate is not licensed for the treatment of osteoporosis in men.

Bisphosphonates are also used in the prevention of osteoporosis in patients at increased fracture risk [4]. The main example of such an indication is the prevention of GIOP. The efficacy of alendronate, risedronate and zoledronate has been demonstrated in the prevention and treatment of GIOP [85–87]. The use of bisphosphonates may be considered for the prevention of secondary osteoporosis in rheumatic diseases, although their efficacy in this indication has been studied almost exclusively in patients receiving GCs [88, 89].

Bisphosphonates may be administered orally (alendronate – 70 mg once weekly, risedronate – 35 mg once weekly, ibandronate – 150 mg once monthly) or intravenously (zoledronate – 5 mg every 12 months, ibandronate – 3 mg every 3 months). The route of administration should be chosen on the basis of the anticipated safety and efficacy profile in the individual patient. Intravenous administration is preferred in patients with contraindications to oral treatment. Where possible, patients' preferences regarding the route and frequency of administration, as well as treatment costs, should be taken into account [4].

There is still no clear evidence on the optimal duration of bisphosphonate therapy or the criteria for restarting treatment after a break, referred to as a "drug holiday" [90]. The indications for and contraindications to continued treatment should be assessed after 5 years of oral bisphosphonate therapy or 3 years of intravenous therapy, or if a new fracture occurs. Although a drug holiday may reduce the risk of adverse events, it increases fracture risk [91]. A treatment break lasting several years increases the risk of clinical fractures by 20–40%, and vertebral fracture risk is approximately doubled [4, 92]. Risk factors for fractures during a drug holiday include low BMD at the time of drug discontinuation (hip *T*-score ≤ –2.5), prior osteoporotic fracture, older age, underweight, and poor adherence to bisphosphonate therapy. During a drug holiday, zoledronate has the most durable anti-fracture effect, particularly after 6 annual infusions [79]. A drug holiday should be considered mainly in patients who are not at high fracture risk, including those without a prior osteoporotic fracture and with a hip *T*-score > –2.5 after 5 years of effective oral bisphosphonate therapy or 3 years of intravenous therapy. During a treatment break, patients should be followed up regularly. Because no validated fracture risk assessment strategy exists for this period, an individualised approach is required. Follow-up BMD testing is recommended 12 months after treatment discontinuation, with further testing at intervals of no more than 2 years. Because evidence is lacking, decisions to restart bisphosphonate therapy or to introduce another anti-osteoporosis drug should be based on an individual assessment of risks and benefits. Factors favouring the resumption of treatment include a new osteoporotic fracture, a hip *T*-score < –2.5 accompanied by a decrease in BMD equal to or greater than the LSC, and the appearance of new fracture risk factors or worsening of existing ones [91]. Data on the safety and efficacy of oral bisphosphonate treatment for > 10 years or intravenous treatment for > 6 years are limited, and therefore decisions about longer continuation of therapy should be made on an individual basis and jointly with patients [91, 92].

The most serious adverse events associated with bisphosphonates, namely atypical femoral fracture (AFF) and osteonecrosis of the jaw (ONJ), are very rare. In 3 randomised clinical trials including more than 14,000 women treated with bisphosphonates for up to 10 years, no cases of AFF or ONJ were observed [91]. The risk of AFF increases with the duration of bisphosphonate use, but this is an increase from 2.5/10,000 person-years with 3 to < 5 years of use to 13.1/10,000 person-years with ≥ 8 years of use [93]. This risk decreases rapidly after drug discontinuation – by as much as 70% per year [94]. In a study including almost 200,000 women treated with bisphosphonates over a 10-year period, the number of osteoporotic fractures prevented by treatment substantially exceeded the number of AFFs at all time points. According to these data, in a hypothetical cohort of 10,000 White women, over 5 years of therapy,

8 AFFs occurred, while 286 hip fractures and 859 clinical fractures were prevented [93]. An even rarer adverse event associated with bisphosphonates is ONJ, and more than 90% of cases occur in patients receiving intravenous bisphosphonate treatment for bone metastases. In the treatment of osteoporosis, the doses used are 6–10 times lower, and ONJ risk at these doses ranges from 1/100,000 to 1/10,000 person-years, only slightly higher than the incidence in the general population [92, 95].

Although invasive oral surgery is a risk factor for ONJ, it does not justify routine interruption of bisphosphonate therapy in patients with osteoporosis. In patients requiring extensive oral surgery and with coexisting ONJ risk factors (e.g. diabetes, periodontal disease, GC therapy, immunodeficiency, smoking), treatment may be withheld until soft tissue healing has occurred. Necessary dental treatment should be completed before bisphosphonates are started, followed by regular dental check-ups [95]. Dental care should not substantially delay osteoporosis treatment.

**Key points:**

- Bisphosphonates are recommended for the treatment of osteoporosis in women and men, including GIOP.
- Bisphosphonates are also used in the prevention of osteoporosis in patients at increased fracture risk.
- Alendronate, risedronate and zoledronate reduce the risk of vertebral and non-vertebral fractures, including hip fractures.
- Ibandronate reduces vertebral fracture risk only and is not licensed for the treatment of osteoporosis in men.

## Denosumab

Denosumab is a human monoclonal IgG2 antibody against receptor activator of nuclear factor-κB ligand (RANKL). It inhibits the binding of RANKL to the receptor RANK on osteoclasts and their precursors, thereby reducing osteoclast differentiation, survival and activity and consequently inhibiting bone resorption. The antiresorptive effect of denosumab is reversible. After denosumab discontinuation, bone turnover increases rapidly, with BMD loss and increased fracture risk, necessitating sequential therapy [96].

Denosumab significantly reduces the risk of vertebral and non-vertebral fractures, including hip fractures. It also significantly increases BMD at the hip and spine [97, 98].

Denosumab is recommended for the treatment of osteoporosis in postmenopausal women at increased fracture risk, osteoporosis in men at increased fracture risk, and for the treatment and prevention of GIOP in adults at increased fracture risk. For these indications, denosumab is administered as a 60 mg subcutaneous injection once every 6 months. The efficacy of denosumab has been confirmed not only in patients who have not previously received any anti-osteoporosis drug, but also as sequential therapy after bisphosphonates, romosozumab or teriparatide [99]. In patients with renal impairment, denosumab may be used at the standard dose, but the higher risk of hypocalcaemia should be taken into account. Hypocalcaemia has been observed most often after the first dose of denosumab and in patients with more advanced stages of chronic kidney disease [100, 101]. In patients with rheumatoid arthritis (RA) and osteoporosis, denosumab reduced the progression of bone erosions, suggesting inhibition of bone resorption in affected joints [102]. No contraindications have been identified for the concomitant use of denosumab with biological disease-modifying antirheumatic drugs in patients with inflammatory rheumatic diseases [102–105].

Among 1,343 women with postmenopausal osteoporosis treated with denosumab in a clinical trial, BMD continued to increase over 10 years of therapy [98]. Data on the safety and efficacy of denosumab treatment for > 10 years are limited, and therefore decisions about longer continuation of therapy should be made on an individual basis and jointly with patients [106, 107].

To maintain the therapeutic effect after stopping denosumab, consolidation therapy with a bisphosphonate should be initiated. Zoledronate or alendronate is recommended for this purpose. The main factors favouring the choice of zoledronate are contraindications to oral therapy, prior vertebral fracture, high fracture risk, and denosumab treatment for > 2.5 years. Consolidation therapy should be started 6 months after the last denosumab injection and continued for at least 1 year. Further decisions should be based on an individual assessment of fracture risk, including the bone densitometry result. The rebound effect after denosumab discontinuation, characterised by rapid BMD loss and increased fracture risk, may last for up to 2 years [108].

The risk of AFF and ONJ during denosumab treatment is low [106]. In a 10-year clinical trial, the incidence rates of AFF and ONJ were 0.8/10,000 person-years and 5.2/10,000 person-years, respectively. No cases of AFF or ONJ were observed during the first 3 years of therapy [98]. In a recently published meta-analysis, no significant association was found between denosumab therapy and ONJ in patients with dental implants, although data on this issue are limited [109].

Necessary dental treatment should be completed before denosumab is started, followed by regular dental check-ups [95]. Dental care should not substantially delay osteoporosis treatment.

**Key points:**

- Denosumab is recommended for the treatment of osteoporosis in postmenopausal women at increased fracture risk, osteoporosis in men at increased fracture risk, and for the treatment and prevention of GIOP in adults at increased fracture risk.
- After stopping denosumab, bisphosphonate treatment should be initiated as sequential therapy.
- Denosumab biosimilars may improve access to osteoporosis treatment and increase its cost-effectiveness.

## Romosozumab

Romosozumab is a humanised monoclonal IgG2 antibody directed against sclerostin. It blocks sclerostin-mediated inhibition of osteoblast proliferation and differentiation, while also reducing RANKL synthesis. This results in increased bone formation and reduced bone resorption [110].

Romosozumab significantly reduces the risk of vertebral and non-vertebral fractures, including hip fractures. It also significantly increases BMD at the hip and spine [110–113].

Romosozumab is recommended for the treatment of severe osteoporosis in postmenopausal women at high fracture risk. In the large clinical trial that confirmed its efficacy, the criterion for high fracture risk was a prior vertebral or hip fracture [112]. Although the greatest efficacy of romosozumab has been demonstrated in patients who have not previously received any anti-osteoporosis drug, its effectiveness has also been confirmed when used after teriparatide, bisphosphonates or denosumab [99, 114]. Because of its anabolic effect, romosozumab is one of the drugs recommended as initial osteoporosis treatment in postmenopausal women at very high fracture risk [43–45]. Preliminary evidence supports the efficacy of romosozumab in the treatment of osteoporosis in women with RA, including those receiving GCs [115–117].

The recommended dose of romosozumab is 210 mg, administered as 2 subcutaneous injections of 105 mg each once monthly for 12 consecutive months. Because the effect of romosozumab is reversible, antiresorptive treatment should be initiated as sequential therapy after its discontinuation. For this purpose, the largest body of evidence is available for denosumab, alendronate and zoledronate [114, 118]. Sequential therapy should be started 1 month after the last dose of romosozumab and continued for at least 1 year. Further decisions should be based on an individual assessment of fracture risk, including the bone densitometry result.

When deciding whether to start romosozumab, the patient's individual cardiovascular risk should be taken into account, and modifiable risk factors should be controlled [110].

**Key points:**

- Romosozumab is recommended for the treatment of severe osteoporosis in postmenopausal women at high fracture risk.
- Because of its anabolic effect, romosozumab is one of the drugs recommended as initial osteoporosis treatment in postmenopausal women at very high fracture risk.
- Romosozumab treatment lasts 12 months.
- After stopping romosozumab, antiresorptive treatment should be initiated as sequential therapy.
- When deciding whether to start romosozumab, the patient's individual cardiovascular risk should be taken into account, and modifiable risk factors should be controlled.

## Teriparatide

Teriparatide is a recombinant, biologically active *N*-terminal fragment of human parathyroid hormone (PTH 1–34). In contrast to continuous overproduction of parathyroid hormone (hyperparathyroidism), intermittent exposure to low doses of parathyroid hormone stimulates bone formation. The anabolic effect of daily teriparatide administration results from stimulation of osteoblast activity and differentiation, with inhibition of osteoblast apoptosis. In addition, teriparatide increases renal calcium reabsorption and phosphate excretion, and promotes hydroxylation of calcifediol to calcitriol, which increases intestinal calcium absorption [119].

Teriparatide significantly reduces the risk of vertebral and non-vertebral fractures. It also significantly increases BMD at the hip and spine. The effect of teriparatide on hip fracture risk could not be reliably assessed in individual clinical trials because too few fractures were observed, but a meta-analysis of 23 randomised clinical trials suggests a significant reduction in this risk. Most evidence for the anti-fracture efficacy of teriparatide comes from studies in postmenopausal women with osteoporosis and a prior low-energy fracture, most commonly a vertebral fracture [120–122].

Teriparatide is recommended for the treatment of osteoporosis in postmenopausal women at increased fracture risk, osteoporosis in men at increased fracture risk, and for the treatment of GIOP in women and men at increased fracture risk. Although the greatest efficacy of teriparatide has been demonstrated in patients who have not previously received any anti-osteoporosis drug, its effectiveness has also been confirmed when used after bisphosphonates. Because teriparatide does not prevent BMD loss after denosumab discontinuation, this treatment sequence is not recommended [99, 123]. Because of its anabolic effect, teriparatide is one of the drugs recommended as initial osteoporosis treatment in

patients at very high fracture risk [43–45]. Preliminary evidence supports the efficacy of teriparatide in the treatment of osteoporosis in postmenopausal women with RA, including those receiving GCs [124, 125].

Teriparatide is administered subcutaneously at a dose of 20 µg daily, and the maximum total duration of treatment is 24 months. Because the effect of teriparatide is reversible, antiresorptive treatment should be initiated as sequential therapy after its discontinuation [45]. For this purpose, the efficacy of bisphosphonates and denosumab has been demonstrated [99, 123]. The effectiveness of romosozumab when used after teriparatide has recently been demonstrated, but this sequence also requires consolidation with an antiresorptive drug [126–128]. Sequential therapy should be started immediately after teriparatide discontinuation and continued for at least 1 year [129]. Further decisions should be based on an individual assessment of fracture risk, including the bone densitometry result.

**Key points:**

- Teriparatide is recommended for the treatment of osteoporosis in postmenopausal women at increased fracture risk, osteoporosis in men at increased fracture risk, and for the treatment of GIOP in women and men at increased fracture risk.
- Because of its anabolic effect, teriparatide is one of the drugs recommended as initial osteoporosis treatment in patients at very high fracture risk.
- The maximum total duration of teriparatide treatment is 24 months.
- After stopping teriparatide, antiresorptive treatment should be initiated as sequential therapy.
- Teriparatide biosimilars may improve access to osteoporosis treatment and increase its cost-effectiveness.

## Menopausal hormone therapy

The use of oestrogens alone or in combination with a progestogen to relieve bothersome menopausal symptoms and prevent BMD loss is referred to as menopausal hormone therapy (MHT) [130].

In healthy postmenopausal women, MHT significantly reduces the risk of vertebral and non-vertebral fractures, including hip fractures. It also significantly increases BMD at the hip and spine. These effects have been demonstrated with 0.625 mg of conjugated equine oestrogens daily [131–133].

Menopausal hormone therapy may be used for the prevention of osteoporosis in postmenopausal women when treatment is aimed primarily at achieving extraskeletal benefits, such as control of vasomotor symptoms of menopause. When deciding whether to initiate or continue MHT, the patient's individual cardiovascular and thromboembolic risk, as well as the risk of breast cancer and gallbladder disease, should be taken into account. Before MHT is initiated, all patients require a full gynaecological assessment, followed by regular follow-up visits. Given its safety profile, initiating MHT in women aged over 60 years or more than 10 years after menopause onset is not recommended. To date, the optimal duration of MHT has not been established, and data from randomised clinical trials are limited to 10 years. Menopausal hormone therapy should be prescribed at the lowest effective dose and for no longer than necessary [130, 133]. After MHT discontinuation, BMD loss accelerates, which should be taken into account in the treatment and monitoring of patients, although the optimal sequential therapy has not yet been established. A randomised clinical trial has demonstrated the efficacy of 12 months of treatment with alendronate in this setting [134–136].

**Key points:**

- Menopausal hormone therapy may be used for the prevention of osteoporosis in postmenopausal women when treatment is aimed primarily at achieving extraskeletal benefits.
- When deciding whether to use MHT, the patient's individual cardiovascular and thromboembolic risk, as well as the risk of breast cancer and gallbladder disease, should be taken into account.
- Initiating MHT in women aged over 60 years or more than 10 years after menopause onset is not recommended.
- Menopausal hormone therapy should be prescribed at the lowest effective dose and for no longer than necessary.
- After MHT discontinuation, BMD loss accelerates, which should be taken into account in the ongoing monitoring and treatment of patients.

## Selective oestrogen receptor modulators

Selective oestrogen receptor modulators are non-hormonal agents that act as agonists or antagonists at oestrogen receptors, depending on the target tissue. In Europe, raloxifene and bazedoxifene are licensed for the treatment of osteoporosis. Both drugs act as partial oestrogen receptor agonists in bone, where they reduce bone resorption through effects on osteoclasts and osteoblasts [137]. Bazedoxifene is not available in Poland and will not be discussed in these recommendations.

Raloxifene significantly reduces the risk of vertebral fractures and significantly increases BMD at the spine and hip. Clinical trials have not demonstrated an effect of raloxifene on the risk of non-vertebral fractures, including hip fractures [138–140]. A reduction in

non-vertebral fracture risk with raloxifene was suggested only by a post hoc analysis in a subgroup of women with severe vertebral fractures [141].

Raloxifene may be used for the treatment and prevention of osteoporosis in postmenopausal women when all other drugs are contraindicated.

Raloxifene is administered at a dose of 60 mg once daily. The optimal duration of raloxifene treatment has not been established, and data from randomised clinical trials are limited to 8 years [142]. Most data are from postmenopausal women aged 50–70 years [143].

Raloxifene significantly reduces the risk of invasive breast cancer, particularly oestrogen receptor-positive disease [142]. It also has a favourable effect on the lipid profile. In women receiving raloxifene, significant reductions in total cholesterol and low-density lipoprotein cholesterol, together with an increase in high-density lipoprotein cholesterol, were found [144]. A significant reduction in atherogenic lipoprotein(a) concentrations was also observed [145].

In clinical trials, raloxifene use was associated with an increased risk of venous thromboembolism, but compared with placebo, this was an increase from 1.3 to 2.2/1000 person-years [146]. Less serious but much more common adverse effects, such as hot flushes, flu syndrome, leg cramps and peripheral oedema, may lead patients to discontinue treatment [138, 139, 143]. When deciding whether to start raloxifene, the patient's individual cardiovascular and thromboembolic risk should be taken into account. In patients undergoing surgery, raloxifene should be discontinued 3 days before planned immobilisation. If immobilisation occurs unexpectedly, raloxifene should be discontinued as soon as possible. Resumption of treatment may be considered once the patient is fully mobile [143].

**Key points:**

- Raloxifene may be used for the treatment and prevention of osteoporosis in postmenopausal women when all other drugs are contraindicated.
- When deciding whether to start raloxifene, the patient's individual cardiovascular and thromboembolic risk should be taken into account.
- Raloxifene may be particularly beneficial in postmenopausal women without marked menopausal symptoms, with concomitant hypercholesterolaemia and/or increased breast cancer risk, if the lack of effect on non-vertebral fracture risk is acceptable.

## Strontium ranelate

Strontium ranelate has been withdrawn from the market in the European Union and will not be discussed in these recommendations [147].

## Calcitonin

Because of its unfavourable benefit-risk balance, calcitonin is not recommended for the treatment of osteoporosis and will not be discussed in this document [148].

## Prevention of glucocorticosteroid-induced osteoporosis

Glucocorticosteroid use is the most common cause of secondary osteoporosis. Treatment with prednisone at doses of ≥ 2.5 mg daily has been shown to increase the risk of hip fractures, whereas the risk of vertebral fractures increases even at doses < 2.5 mg daily. The most rapid BMD loss occurs within the first 3–6 months of treatment. Therefore, prevention of GIOP should be considered at the initiation of GC therapy. Glucocorticoid therapy should be used at the lowest effective dose and for no longer than necessary. It is important to ensure adequate calcium intake, optimal vitamin D status, and control of other risk factors for accelerated BMD loss. In patients beginning or continuing GC therapy at a prednisone-equivalent dose of ≥ 2.5 mg daily for > 3 months, a comprehensive fracture risk assessment is recommended, including bone densitometry and either VFA or spine radiographs. Subsequent fracture risk assessments during GC therapy are recommended at least every 12 months. In patients beginning or continuing GC therapy at a prednisone-equivalent dose of ≥ 2.5 mg daily for > 3 months, the initiation of antiresorptive treatment should be considered for the prevention of GIOP. After GCs are discontinued, fracture risk should be reassessed and a decision made about whether to continue, modify or stop antiresorptive treatment. If denosumab is being discontinued, consolidation therapy with a bisphosphonate is required. After discontinuation of an anti-osteoporosis drug used for GIOP prevention, regular fracture risk assessment every 1–2 years is recommended, including bone densitometry and, ideally, VFA. The prevention and treatment of GIOP should follow the 2022 American College of Rheumatology (ACR) guideline, which summarises the clinical evidence in this area [53].

**Key points:**

- Glucocorticosteroid therapy should be used at the lowest effective dose and for the shortest possible duration.
- In patients beginning or continuing GC therapy at a prednisone-equivalent dose of ≥ 2.5 mg daily for > 3 months, a comprehensive fracture risk assessment is recommended, including bone densitometry and either VFA or spine radiographs.
- Subsequent fracture risk assessments during GC therapy are recommended at least every 12 months.

- In patients beginning or continuing GC therapy at a prednisone-equivalent dose of ≥ 2.5 mg daily for > 3 months, the initiation of antiresorptive treatment should be considered for the prevention of GIOP.
- The prevention and treatment of GIOP should follow the ACR guideline.

### Treatment of osteoporosis in premenopausal women

In premenopausal women, osteoporosis is most often secondary, resulting from chronic diseases (e.g. inflammatory rheumatic diseases, endocrine, neuromuscular, haematological, pulmonary, gastrointestinal or infectious diseases, and eating disorders) or from their treatment (e.g. GCs, antiepileptic drugs or antiretroviral drugs). In rare cases, when an osteoporotic fracture has occurred and comprehensive diagnostic assessment has not identified a cause of secondary osteoporosis, idiopathic osteoporosis is diagnosed. Decisions about the treatment of osteoporosis in premenopausal women should be made on an individual basis in specialist centres. The treatment goal and monitoring approach are the same as those in postmenopausal women. In every case, optimal treatment of the underlying diseases should be ensured and the use of osteotoxic drugs limited where possible. Non-pharmacological management includes a well-balanced diet, exercise that stimulates bone formation, and prevention of falls. Pharmacological treatment begins with vitamin D and calcium supplementation at recommended doses, taking into account age, body weight, diet and comorbidities. In women at high fracture risk, particularly after a low-energy fracture, the initiation of antiresorptive or anabolic treatment should be considered. To date, no studies have assessed the effect of anti-osteoporosis drugs on fracture risk in premenopausal women. However, effects on BMD and bone microarchitecture have been demonstrated. The largest body of evidence in this area is available for bisphosphonates (zoledronate, risedronate and alendronate), with less evidence for teriparatide [149, 150]. More recently, the efficacy of denosumab as sequential therapy after teriparatide has been demonstrated in the treatment of osteoporosis in premenopausal women [151, 152]. In addition, a significant increase in lumbar spine BMD was found in a small retrospective study assessing the efficacy of romosozumab in premenopausal women with osteoporosis and anorexia nervosa [153].

**Key points:**

- Secondary osteoporosis is the most common form of osteoporosis in premenopausal women.
- In every case, optimal treatment of the underlying diseases should be ensured, and the use of osteotoxic drugs should be limited where possible.
- Decisions about the treatment of osteoporosis in premenopausal women should be made on an individual basis in specialist centres.
- In the treatment of osteoporosis in premenopausal women, the largest body of evidence on efficacy and safety is available for bisphosphonates (zoledronate, risedronate and alendronate), with less evidence for teriparatide.
- Randomised clinical trials assessing the efficacy of new anti-osteoporosis drugs in premenopausal women are needed, as are studies assessing the anti-fracture efficacy of all drugs in this population.

## Diagnosis and treatment of osteoporosis in the paediatric population

Because osteoporosis in children and adolescents has a highly diverse aetiology, it requires an individualised approach based on current recommendations for the specific form of the disease and the patient's age. The general principles for the diagnosis and treatment of osteoporosis in the paediatric population are presented below.

### Diagnostic criteria for osteoporosis in the paediatric population

According to the ISCD Official Positions, osteoporosis is diagnosed in children and adolescents when at least one of the following criteria is met [26]:

– at least one low-energy vertebral compression fracture, after exclusion of causes other than osteoporosis, or
– a clinically significant fracture history, defined as at least 2 long bone fractures by 10 years of age or at least 3 long bone fractures by 19 years of age, together with a BMD *Z*-score of ≤ –2.0.

In children and adolescents, as in young adults, osteoporosis cannot be diagnosed on the basis of the bone densitometry result alone. In the paediatric population, BMD is assessed by DXA. The recommended site for assessment of BMD and/or bone mineral content is the lumbar spine (vertebrae L1–L4) in the PA projection, and from 3 years of age, assessment of total body less head is also recommended. When interpreting bone densitometry results, bone age and/or Tanner stage should be taken into account. The referring physician is responsible for providing these data [26].

In children and adolescents, a low-energy vertebral compression fracture is sufficient to establish the diagnosis of osteoporosis after other causes have been excluded. Therefore, in the paediatric population, back pain requires careful differential diagnosis, including consideration of lateral radiography of the thoracic and lumbar spine. This examination should also be performed

in all children with suspected osteoporosis or increased fracture risk to identify asymptomatic fractures [154]. Vertebral fractures are assessed using the Genant semi-quantitative method. Vertebral fracture assessment may be used to detect vertebral compression fractures in children and adolescents, providing reliable assessment of moderate and severe fractures (Genant grades 2 and 3) at a lower radiation dose than standard radiography. After VFA, additional imaging should be considered in the following situations [26]:

– when some vertebrae could not be assessed by VFA and detection of a fracture would change clinical management,
– when VFA shows a single Genant grade 1 vertebral fracture and confirmation of this finding would change clinical management,
– when VFA shows radiological features atypical of an osteoporotic fracture, for example findings suggestive of malignancy or a congenital abnormality.

The differential diagnosis of osteoporosis in children and adolescents should begin by excluding rickets/osteomalacia. It is also necessary to distinguish traumatic fractures from low-energy fractures, which can be challenging in this patient group. The next step is a comprehensive clinical assessment aimed at identifying causes of both primary osteoporosis (e.g. osteogenesis imperfecta) and secondary osteoporosis. In children and adolescents, osteoporosis is most often secondary, resulting from chronic diseases (e.g. inflammatory rheumatic diseases, inflammatory bowel disease, neuromuscular, haematological or endocrine diseases, chronic kidney disease, malabsorption syndromes and eating disorders) or from their treatment (e.g. GCs, antiepileptic drugs or radiotherapy). A diagnosis of secondary osteoporosis does not exclude coexisting primary osteoporosis, and vice versa [154–156].

### Treatment of osteoporosis in the paediatric population

The goals of osteoporosis treatment in the paediatric population include reducing the risk of subsequent fractures, promoting bone mass accrual, preventing postural deformities, and improving or maintaining physical function. The developing skeleton has a high regenerative capacity, including the ability of fractured vertebral bodies to regain their shape (reshaping). Non-pharmacological management includes a well-balanced diet, exercise that stimulates bone formation, and prevention of falls. Pharmacological treatment begins with vitamin D and calcium supplementation at recommended doses, taking into account age, body weight, diet and comorbidities. Diseases affecting bone metabolism should be treated optimally, and the use of osteotoxic drugs, especially GCs, should be limited where possible. Decisions about the treatment of osteoporosis in children and adolescents should be made on an individual basis in specialist centres. Meeting the ISCD diagnostic criteria for osteoporosis is considered an indication for antiresorptive therapy, although no drug is licensed for the treatment of osteoporosis in children and adolescents. The largest body of evidence is available for bisphosphonates, for which safety and efficacy have been demonstrated in osteogenesis imperfecta, idiopathic juvenile osteoporosis and secondary osteoporosis. In children and adolescents, intravenous bisphosphonate therapy is preferred. This preference reflects the greatest clinical experience, the best documented efficacy and ease of treatment administration. Standardised dosing regimens have not yet been established. Examples include the following: zoledronate 0.05 mg/kg body weight every 6 months, pamidronate in children older than 3 years at a dose of 1 mg/kg body weight/day for 3 consecutive days every 4 months, and neridronate 2 mg/kg body weight every 3 months. In patients who have not sustained new fractures in the previous 12 months, stopping treatment or gradually reducing bisphosphonate doses should be considered [155–158]. Monitoring during and after osteoporosis treatment follows the general principles used in adults, while taking into account the specific features of the paediatric population and recommendations for the particular form of the disease and the patient's age.

**Key points:**

- The diagnosis of osteoporosis in children and adolescents requires evidence of low-energy fractures whose type and number are strictly defined.
- Bone mineral density is assessed by DXA.
- Osteoporosis in children and adolescents is most often secondary.
- In every case, optimal treatment of the underlying diseases should be ensured, and the use of osteotoxic drugs, especially GCs, should be limited.
- Meeting the diagnostic criteria for osteoporosis in the paediatric population is an indication for antiresorptive therapy.
- In the treatment of osteoporosis in children and adolescents, intravenous bisphosphonate therapy is preferred.
- In patients who have not sustained new fractures in the previous 12 months, stopping treatment or gradually reducing bisphosphonate doses should be considered.

## Conclusions

These recommendations present current principles for the diagnosis and treatment of osteoporosis. The pri-

mary aim was to provide physicians and patients with a wide range of therapeutic options informed by current evidence. The document was prepared on the principle that clinical recommendations should be guided by medical evidence rather than reimbursement criteria, which may restrict treatment options for non-medical reasons. The authors hope that these PTR recommendations will contribute to early diagnosis and effective treatment of osteoporosis in Poland.

## Disclosures

*Conflict of interest: Payment or honoraria for lectures, presentations, speakers bureaus, manuscript writing or educational events: AbbVie, Amgen, Angelini Pharma, AstraZeneca, Biogen, Boehringer Ingelheim, Bristol Myers Squibb, Celltrion, CSL Behring, Eli Lilly, GSK Commercial, Janssen-Cilag, Johnson & Johnson, Medac, Merck Sharp & Dohme, Novartis, Pfizer, Roche, Sandoz, SUN-FARM, Swedish Orphan Biovitrum, Teva, UCB, VEDIM. Support for attending meetings and/or travel: AbbVie, Amgen, Angelini Pharma, Boehringer Ingelheim, Egis, Eli Lilly, Janssen-Cilag, Medac, Novartis, Sandoz, Swedish Orphan Biovitrum. Participation on a data safety monitoring board or advisory board: AstraZeneca, Boehringer Ingelheim, Janssen-Cilag, Roche, UCB. No company had any influence on the content of these recommendations or on the decision to publish them.*

*Funding: No external funding.*

*Ethics approval: Not applicable.*

*Data availability: Not applicable.*

### References

1. Willers C, Norton N, Harvey NC, et al. Osteoporosis in Europe: a compendium of country-specific reports. Arch Osteoporos 2022; 17: 23, DOI: 10.1007/s11657-021-00969-8.
2. Leszczyński P, Korkosz M, Pawlak-Buś K, et al. Diagnostyka i leczenie osteoporozy – zalecenia Polskiego Towarzystwa Reumatologicznego 2015. Forum Reumatol 2015; 1: 12–24. [Article in Polish].
3. Peck WA, Burckhardt P, Christiansen C, et al. Consensus development conference: diagnosis, prophylaxis, and treatment of osteoporosis. Am J Med 1993; 94: 646–650, DOI: 10.1016/0002-9343(93)90218-E.
4. Kanis JA, Cooper C, Rizzoli R, et al. European guidance for the diagnosis and management of osteoporosis in postmenopausal women. Osteoporos Int 2019; 30: 3–44, DOI: 10.1007/s00198-018-4704-5.
5. Krueger D, Tanner SB, Szalat A, et al. DXA reporting updates: 2023 official positions of the International Society for Clinical Densitometry. J Clin Densitom 2024; 27: 101437, DOI: 10.1016/j.jocd.2023.101437.
6. Iwaszkiewicz C, Leszczyński P. Bone densitometry by radiofrequency echographic multi-spectrometry (REMS) in the diagnosis of osteoporosis. Forum Reumatol 2019; 5: 81–88, DOI: 10.5603/FR.2019.0011.
7. Echolight S.p.A. EchoS 510(k) Premarket Notification. Available at: https://www.accessdata.fda.gov/cdrh_docs/pdf18/K180516.pdf (Access: 21.03.2026).
8. Echolight S.p.A. EchoS Family 510(k) Premarket Notification. Available at: https://www.accessdata.fda.gov/cdrh_docs/pdf20/K202514.pdf (Access: 21.03.2026).
9. Diez-Perez A, Brandi ML, Al-Daghri N, et al. Radiofrequency echographic multi-spectrometry for the in-vivo assessment of bone strength: state of the art – outcomes of an expert consensus meeting organized by the European Society for Clinical and Economic Aspects of Osteoporosis, Osteoarthritis and Musculoskeletal Diseases (ESCEO). Aging Clin Exp Res 2019; 31: 1375–1389, DOI: 10.1007/s40520-019-01294-4.
10. Adami G, Arioli G, Bianchi G, et al. Radiofrequency echographic multi spectrometry for the prediction of incident fragility fractures: a 5-year follow-up study. Bone 2020; 134: 115297, DOI: 10.1016/j.bone.2020.115297.
11. Cortet B, Dennison E, Diez-Perez A, et al. Radiofrequency echographic multi spectrometry (REMS) for the diagnosis of osteoporosis in a European multicenter clinical context. Bone 2021; 143: 115786, DOI: 10.1016/j.bone.2020.115786.
12. Icătoiu E, Vlădulescu-Trandafir AI, Groșeanu LM, et al. Radiofrequency echographic multi spectrometry – a novel tool in the diagnosis of osteoporosis and prediction of fragility fractures: a systematic review. Diagnostics (Basel) 2025; 15: 555, DOI: 10.3390/diagnostics15050555.
13. Fuggle NR, Reginster JY, Al-Daghri N, et al. Radiofrequency echographic multi spectrometry (REMS) in the diagnosis and management of osteoporosis: state of the art. Aging Clin Exp Res 2024; 36: 135, DOI: 10.1007/s40520-024-02784-w.
14. Caffarelli C, Tomai Pitinca MD, Al Refaie A, et al. Could radiofrequency echographic multispectrometry (REMS) overcome the overestimation in BMD by dual-energy X-ray absorptiometry (DXA) at the lumbar spine? BMC Musculoskelet Disord 2022; 23: 469, DOI: 10.1186/s12891-022-05430-6.
15. Messina C, Fusco S, Gazzotti S, et al. DXA beyond bone mineral density and the REMS technique: new insights for current radiologists practice. Radiol Med 2024; 129: 1224–1240, DOI: 10.1007/s11547-024-01843-6.
16. Zambito K, Kushchayeva Y, Bush A, et al. Proposed practice parameters for the performance of radiofrequency echographic multispectrometry (REMS) evaluations. Bone Jt Open 2025; 6: 291–297, DOI: 10.1302/2633-1462.63.BJO-2024-0107.R1.
17. Harlow SD, Gass M, Hall JE, et al. Executive summary of the Stages of Reproductive Aging Workshop + 10: addressing the unfinished agenda of staging reproductive aging. J Clin Endocrinol Metab 2012; 97: 1159–1168, DOI: 10.1210/jc.2011-3362.
18. Spiro AJ, Hoang TD, Shakir MKM. Artifacts affecting dual-energy X-ray absorptiometry measurements. AACE Clin Case Rep 2019; 5: e263–e266, DOI: 10.4158/ACCR-2019-0031.
19. Qutbi M, Soltanshahi M, Shiravand Y, et al. Technical and patient-related sources of error and artifacts in bone mineral densitometry using dual-energy X-ray absorptiometry: a pictorial review. Indian J Radiol Imaging 2020; 30: 362–371, DOI: 10.4103/ijri.IJRI_495_19.

20. White K, Shakir MKM, Nguyen C, Hoang TD. Artifacts affecting dual-energy X-ray absorptiometry and bone mineral density measurements: a case report and review of the literature. J Med Case Rep 2025; 19: 290, DOI: 10.1186/s13256-025-05353-5.
21. Yoon BH, Kim DY. Discordance between hip and spine bone mineral density: a point of care. J Bone Metab 2021; 28: 249–251, DOI: 10.11005/jbm.2021.28.4.249.
22. Singh T, Ghosh A, Khandelwal N, et al. Major and minor discordance in dual-energy X-ray absorptiometry diagnosis of osteoporosis – a cross-sectional, population-based, observational study in Indian women. J Midlife Health 2020; 11: 12–16, DOI: 10.4103/jmh.JMH_117_19.
23. White VanGompel EC, Franks P, Robbins JA, Fenton JJ. Incidence and predictors of repeat bone mineral densitometry: a longitudinal cohort study. J Gen Intern Med 2017; 32: 1090–1096, DOI: 10.1007/s11606-017-4094-y.
24. Kobza AO, Herman D, Papaioannou A, et al. Understanding and managing corticosteroid-induced osteoporosis. Open Access Rheumatol 2021; 13: 177–190, DOI: 10.2147/OARRR.S282606.
25. Miller PD. Guidelines for the diagnosis of osteoporosis: T-scores vs fractures. Rev Endocr Metab Disord 2006; 7: 75–89, DOI: 10.1007/s11154-006-9006-0.
26. Shuhart CR, Yeap SS, Anderson PA, et al. Executive summary of the 2019 ISCD position development conference on monitoring treatment, DXA cross-calibration and least significant change, spinal cord injury, peri-prosthetic and orthopedic bone health, transgender medicine, and pediatrics. J Clin Densitom 2019; 22: 453–471, DOI: 10.1016/j.jocd.2019.07.001.
27. Mai HT, Tran TS, Ho-Le TP, et al. Two-thirds of all fractures are not attributable to osteoporosis and advancing age: implications for fracture prevention. J Clin Endocrinol Metab 2019; 104: 3514–3520, DOI: 10.1210/jc.2018-02614.
28. Siris E, Adler R, Bilezikian J, et al. The clinical diagnosis of osteoporosis: a position statement from the National Bone Health Alliance Working Group. Osteoporos Int 2014; 25: 1439–1443, DOI: 10.1007/s00198-014-2655-z.
29. Curtis JR, Taylor AJ, Matthews RS, et al. "Pathologic" fractures: should these be included in epidemiologic studies of osteoporotic fractures? Osteoporos Int 2009; 20: 1969–1972, DOI: 10.1007/s00198-009-0840-2.
30. Kanis JA, Johansson H, Harvey NC, et al. Adjusting conventional FRAX estimates of fracture probability according to the recency of sentinel fractures. Osteoporos Int 2020; 31: 1817–1828, DOI: 10.1007/s00198-020-05517-7.
31. Ariie T, Yamamoto N, Tsutsumi Y, et al. Association between a history of major osteoporotic fractures and subsequent hip fracture: a systematic review and meta-analysis. Arch Osteoporos 2024; 19: 44, DOI: 10.1007/s11657-024-01393-4.
32. Warriner AH, Patkar NM, Curtis JR, et al. Which fractures are most attributable to osteoporosis? J Clin Epidemiol 2011; 64: 46–53, DOI: 10.1016/j.jclinepi.2010.07.007.
33. Weiss RJ, Wick MC, Ackermann PW, Montgomery SM. Increased fracture risk in patients with rheumatic disorders and other inflammatory diseases - a case-control study with 53,108 patients with fracture. J Rheumatol 2010; 37: 2247–2250, DOI: 10.3899/jrheum.100363.
34. Mok CC, Tse SM, Chan KL, Ho LY. Estimation of fracture risk by the FRAX tool in patients with systemic lupus erythematosus: a 10-year longitudinal validation study. Ther Adv Musculoskelet Dis 2022; 14: 1759720X221074451, DOI: 10.1177/1759720X221074451.
35. Vincze A, Gaál J, Griger Z. Bone health in idiopathic inflammatory myopathies: diagnosis and management. Curr Rheumatol Rep 2021; 23: 55, DOI: 10.1007/s11926-021-01016-8.
36. Compston J. Glucocorticoid-induced osteoporosis: an update. Endocrine 2018; 61: 7–16, DOI: 10.1007/s12020-018-1588-2.
37. Kanis JA, Johansson H, McCloskey EV, et al. Rheumatoid arthritis and subsequent fracture risk: an individual person meta-analysis to update FRAX. Osteoporos Int 2025; 36: 653–671, DOI: 10.1007/s00198-025-07397-1.
38. Lopez C, Parisi S, Parasiliti-Caprino M, et al. Disease activity score is associated with vertebral fragility fractures in patients with rheumatoid arthritis: a cross-sectional multidisciplinary study. Rheumatol Int 2025; 45: 133, DOI: 10.1007/s00296-025-05877-5.
39. Salman-Monte TC, Sanchez-Piedra C, Fernandez Castro M, et al. Prevalence and factors associated with osteoporosis and fragility fractures in patients with primary Sjögren syndrome. Rheumatol Int 2020; 40: 1259–1265, DOI: 10.1007/s00296-020-04615-3.
40. Siris ES, Baim S, Nattiv A. Primary care use of FRAX: absolute fracture risk assessment in postmenopausal women and older men. Postgrad Med 2010; 122: 82–90, DOI: 10.3810/pgm.2010.01.2102.
41. El Miedany Y. FRAX: re-adjust or re-think. Arch Osteoporos 2020; 15: 150, DOI: 10.1007/s11657-020-00827-z.
42. Schini M, Johansson H, Harvey NC, et al. An overview of the use of the fracture risk assessment tool (FRAX) in osteoporosis. J Endocrinol Invest 2024; 47: 501–511, DOI: 10.1007/s40618-023-02219-9.
43. Veronese N, Briot K, Guañabens N, et al. Recommendations for the optimal use of bone forming agents in osteoporosis. Aging Clin Exp Res 2024; 36: 167, DOI: 10.1007/s40520-024-02826-3.
44. Cosman F, Lewiecki EM, Eastell R, et al. Goal-directed osteoporosis treatment: ASBMR/BHOF task force position statement 2024. J Bone Miner Res 2024; 39: 1393–1405, DOI: 10.1093/jbmr/zjae119.
45. Curtis EM, Reginster JY, Al-Daghri N, et al. Management of patients at very high risk of osteoporotic fractures through sequential treatments. Aging Clin Exp Res 2022; 34: 695–714, DOI: 10.1007/s40520-022-02100-4.
46. Shevroja E, Reginster JY, Lamy O, et al. Update on the clinical use of trabecular bone score (TBS) in the management of osteoporosis: results of an expert group meeting organized by the European Society for Clinical and Economic Aspects of Osteoporosis, Osteoarthritis and Musculoskeletal Diseases (ESCEO), and the International Osteoporosis Foundation (IOF) under the auspices of WHO Collaborating Center for Epidemiology of Musculoskeletal Health and Aging. Osteoporos Int 2023; 34: 1501–1529, DOI: 10.1007/s00198-023-06817-4.
47. McCloskey EV, Odén A, Harvey NC, et al. A meta-analysis of trabecular bone score in fracture risk prediction and its relationship to FRAX. J Bone Miner Res 2016; 31: 940–948, DOI: 10.1002/jbmr.2734.

48. Vasikaran S, Eastell R, Bruyère O, et al. Markers of bone turnover for the prediction of fracture risk and monitoring of osteoporosis treatment: a need for international reference standards. Osteoporos Int 2011; 22: 391–420, DOI: 10.1007/s00198-010-1501-1.
49. Brescia V, Lovero R, Fontana A, et al. Reference intervals (RIs) of the bone turnover markers (BTMs) in children and adolescents: a proposal for effective use. Biomedicines 2024; 13: 34, DOI: 10.3390/biomedicines13010034.
50. Bhattoa HP, Cavalier E, Eastell R, et al. Analytical considerations and plans to standardize or harmonize assays for the reference bone turnover markers PINP and β-CTX in blood. Clin Chim Acta 2021; 515: 16–20, DOI: 10.1016/j.cca.2020.12.023.
51. Schini M, Vilaca T, Gossiel F, et al. Bone turnover markers: basic biology to clinical applications. Endocr Rev 2023; 44: 417–473, DOI: 10.1210/endrev/bnac031.
52. Lewiecki EM. Operationalizing treat-to-target for osteoporosis. Endocrinol Metab (Seoul) 2021; 36: 270–278, DOI: 10.3803/EnM.2021.970.
53. Humphrey MB, Russell L, Danila MI, et al. 2022 American College of Rheumatology guideline for the prevention and treatment of glucocorticoid-induced osteoporosis. Arthritis Rheumatol 2023; 75: 2088–2102, DOI: 10.1002/art.42646.
54. Montero-Odasso M, van der Velde N, Martin FC, et al. World guidelines for falls prevention and management for older adults: a global initiative. Age Ageing 2022; 51: afac205, DOI: 10.1093/ageing/afac205.
55. O'Reilly T, Gómez Lemus J, Booth L, et al. Potentially inappropriate prescribing and falls-risk increasing drugs in people who have experienced a fall: a systematic review and meta-analysis. Age Ageing 2025; 54: afaf300, DOI: 10.1093/ageing/afaf300.
56. Pillay J, Gaudet LA, Saba S, et al. Falls prevention interventions for community-dwelling older adults: systematic review and meta-analysis of benefits, harms, and patient values and preferences. Syst Rev 2024; 13: 289, DOI: 10.1186/s13643-024-02681-3.
57. Dyer SM, Kwok WS, Suen J, et al. Interventions for preventing falls in older people in care facilities. Cochrane Database Syst Rev 2025; 8: CD016064, DOI: 10.1002/14651858.CD016064.
58. Bae S, Lee S, Park H, et al. Position statement: exercise guidelines for osteoporosis management and fall prevention in osteoporosis patients. J Bone Metab 2023; 30: 149–165, DOI: 10.11005/jbm.2023.30.2.149.
59. Benedetti MG, Furlini G, Zati A, Letizia Mauro G. The effectiveness of physical exercise on bone density in osteoporotic patients. Biomed Res Int 2018; 2018: 4840531, DOI: 10.1155/2018/4840531.
60. Lee D, Tak SH, Choi H. A systematic review of fall prevention interventions in frail older adults. Geriatr Nurs 2025; 62: 236–244, DOI: 10.1016/j.gerinurse.2025.02.018.
61. Sherrington C, Fairhall NJ, Wallbank GK, et al. Exercise for preventing falls in older people living in the community. Cochrane Database Syst Rev 2019; 1: CD012424, DOI: 10.1002/14651858.CD012424.pub2.
62. Muñoz-Garach A, García-Fontana B, Muñoz-Torres M. Nutrients and dietary patterns related to osteoporosis. Nutrients 2020; 12: 1986, DOI: 10.3390/nu12071986.
63. Tan B, Su H, Wei L, Liang M. Association of dietary patterns with osteoporosis risk: a meta-analysis of observational studies. J Orthop Surg Res 2025; 20: 551, DOI: 10.1186/s13018-025-05896-9.
64. Chen X, Fu Y, Zhu Z. Association between dietary protein intake and bone mineral density based on NHANES 2011-2018. Sci Rep 2025; 15: 8638, DOI: 10.1038/s41598-025-93642-w.
65. Shea B, Wells G, Cranney A, et al. Calcium supplementation on bone loss in postmenopausal women. Cochrane Database Syst Rev 2004; 1: CD004526, DOI: 10.1002/14651858.CD004526.pub2.
66. Iwaszkiewicz C, Leszczyński P. The significance of vitamin D in adult orthopaedics and traumatology. Ortop Traumatol Rehabil 2023; 25: 279–285, DOI: 10.5604/01.3001.0053.9676.
67. Wei FL, Li T, Gao QY, et al. Association between vitamin D supplementation and fall prevention. Front Endocrinol (Lausanne) 2022; 13: 919839, DOI: 10.3389/fendo.2022.919839.
68. Płudowski P, Ducki C, Konstantynowicz J, Jaworski M. Vitamin D status in Poland. Pol Arch Med Wewn 2016; 126: 530–539, DOI: 10.20452/pamw.3479.
69. Pludowski P, Takacs I, Boyanov M, et al. Clinical practice in the prevention, diagnosis and treatment of vitamin D deficiency: a Central and Eastern European expert consensus statement. Nutrients 2022; 14: 1483, DOI: 10.3390/nu14071483.
70. Balachandar R, Pullakhandam R, Kulkarni B, Sachdev HS. Relative efficacy of vitamin D2 and vitamin D3 in improving vitamin D status: systematic review and meta-analysis. Nutrients 2021; 13: 3328, DOI: 10.3390/nu13103328.
71. Rupprecht M, Wagenpfeil S, Schöpe J, et al. Meta-analysis of European clinical trials characterizing the healthy-adult serum 25-hydroxyvitamin D response to vitamin D supplementation. Nutrients 2023; 15: 3986, DOI: 10.3390/nu15183986.
72. Rastogi A, Bhansali A, Khare N, et al. Short term, high-dose vitamin D supplementation for COVID-19 disease: a randomised, placebo-controlled study (SHADE study). Postgrad Med J 2022; 98: 87–90, DOI: 10.1136/postgradmedj-2020-139065.
73. McCullough P, Amend J. Results of daily oral dosing with up to 60,000 international units (iu) of vitamin D3 for 2 to 6 years in 3 adult males. J Steroid Biochem Mol Biol 2017; 173: 308–312, DOI: 10.1016/j.jsbmb.2016.12.009.
74. Bertoldo F, Cianferotti L, Di Monaco M, et al. Definition, assessment, and management of vitamin D inadequacy: suggestions, recommendations, and warnings from the Italian Society for Osteoporosis, Mineral Metabolism and Bone Diseases (SIOMMMS). Nutrients 2022; 14: 4148, DOI: 10.3390/nu14194148.
75. Avenell A, Mak JC, O'Connell D. Vitamin D and vitamin D analogues for preventing fractures in post-menopausal women and older men. Cochrane Database Syst Rev 2014; 2014: CD000227, DOI: 10.1002/14651858.CD000227.pub4.
76. Mott A, Bradley T, Wright K, et al. Effect of vitamin K on bone mineral density and fractures in adults: an updated systematic review and meta-analysis of randomised controlled trials. Osteoporos Int 2019; 30: 1543–1559, DOI: 10.1007/s00198-019-04949-0.
77. Foessl I, Dimai HP, Obermayer-Pietsch B. Long-term and sequential treatment for osteoporosis. Nat Rev Endocrinol 2023; 19: 520–533, DOI: 10.1038/s41574-023-00866-9.
78. Vannala V, Palaian S, Shankar PR. Therapeutic dimensions of bisphosphonates: a clinical update. Int J Prev Med 2020; 11: 166, DOI: 10.4103/ijpvm.IJPVM_33_19.

79. Wang M, Wu YF, Girgis CM. Bisphosphonate drug holidays: evidence from clinical trials and real-world studies. JBMR Plus 2022; 6: e10629, DOI: 10.1002/jbm4.10629.
80. Bastounis A, Langley T, Davis S, et al. Assessing the effectiveness of bisphosphonates for the prevention of fragility fractures: an updated systematic review and network meta-analyses. JBMR Plus 2022; 6: e10620, DOI: 10.1002/jbm4.10620.
81. Zhou J, Ma X, Wang T, Zhai S. Comparative efficacy of bisphosphonates in short-term fracture prevention for primary osteoporosis: a systematic review with network meta-analyses. Osteoporos Int 2016; 27: 3289–3300, DOI: 10.1007/s00198-016-3654-z.
82. Wells GA, Hsieh SC, Peterson J, et al. Alendronate for the primary and secondary prevention of osteoporotic fractures in postmenopausal women. Cochrane Database Syst Rev 2025; 1: CD001155, DOI: 10.1002/14651858.CD001155.pub3.
83. Byun JH, Jang S, Lee S, et al. The efficacy of bisphosphonates for prevention of osteoporotic fracture: an update meta-analysis. J Bone Metab 2017; 24: 37–49, DOI: 10.11005/jbm.2017.24.1.37.
84. Chesnut CH, Skag A, Christiansen C, et al. Effects of oral ibandronate administered daily or intermittently on fracture risk in postmenopausal osteoporosis. J Bone Miner Res 2004; 19: 1241–1249, DOI: 10.1359/JBMR.040325.
85. Laurent MR, Goemaere S, Verroken C, et al. Prevention and treatment of glucocorticoid-induced osteoporosis in adults: consensus recommendations from the Belgian Bone Club. Front Endocrinol (Lausanne) 2022; 13: 908727, DOI: 10.3389/fendo.2022.908727.
86. Hayat S, Magrey MN. Glucocorticoid-induced osteoporosis: insights for the clinician. Cleve Clin J Med 2020; 87: 417–426, DOI: 10.3949/ccjm.87a.19039.
87. Allen CS, Yeung JH, Vandermeer B, Homik J. Bisphosphonates for steroid-induced osteoporosis. Cochrane Database Syst Rev 2016; 10: CD001347, DOI: 10.1002/14651858.CD001347.pub2.
88. Feng Z, Zeng S, Wang Y, et al. Bisphosphonates for the prevention and treatment of osteoporosis in patients with rheumatic diseases: a systematic review and meta-analysis. PLoS One 2013; 8: e80890, DOI: 10.1371/journal.pone.0080890.
89. Peris P, Monegal A, Guañabens N. Bisphosphonates in inflammatory rheumatic diseases. Bone 2021; 146: 115887, DOI: 10.1016/j.bone.2021.115887.
90 Adams AL. Fracture risk during and after bisphosphonate drug holidays: a matter of methods? Med Care 2020; 58: 417–418, DOI: 10.1097/MLR.0000000000001317.
91. Bauer DC, Abrahamsen B. Bisphosphonate drug holidays in primary care: when and what to do next? Curr Osteoporos Rep 2021; 19: 182–188, DOI: 10.1007/s11914-021-00660-4.
92. Dennison EM, Cooper C, Kanis JA, et al. Fracture risk following intermission of osteoporosis therapy. Osteoporos Int 2019; 30: 1733–1743, DOI: 10.1007/s00198-019-05002-w.
93. Black DM, Geiger EJ, Eastell R, et al. Atypical femur fracture risk versus fragility fracture prevention with bisphosphonates. N Engl J Med 2020; 383: 743–753, DOI: 10.1056/NEJMoa1916525.
94. Schilcher J, Michaëlsson K, Aspenberg P. Bisphosphonate use and atypical fractures of the femoral shaft. N Engl J Med 2011; 364: 1728–1737, DOI: 10.1056/NEJMoa1010650.
95. Khan AA, Morrison A, Hanley DA, et al. Diagnosis and management of osteonecrosis of the jaw: a systematic review and international consensus. J Bone Miner Res 2015; 30: 3–23, DOI: 10.1002/jbmr.2405.
96. Ferrari S, Langdahl B. Mechanisms underlying the long-term and withdrawal effects of denosumab therapy on bone. Nat Rev Rheumatol 2023; 19: 307–317, DOI: 10.1038/s41584-023-00935-3.
97. Cummings SR, San Martin J, McClung MR, et al. Denosumab for prevention of fractures in postmenopausal women with osteoporosis. N Engl J Med 2009; 361: 756–765, DOI: 10.1056/NEJMoa0809493.
98. Bone HG, Wagman RB, Brandi ML, et al. 10 years of denosumab treatment in postmenopausal women with osteoporosis: results from the phase 3 randomised FREEDOM trial and open-label extension. Lancet Diabetes Endocrinol 2017; 5: 513–523, DOI: 10.1016/S2213-8587(17)30138-9.
99. Nayak S, Greenspan SL. A systematic review and meta-analysis of sequential treatment strategies for osteoporosis. Osteoporos Int 2026; 37: 1–13, DOI: 10.1007/s00198-025-07717-5.
100. Broadwell A, Chines A, Ebeling PR, et al. Denosumab safety and efficacy among participants in the FREEDOM Extension Study with mild to moderate chronic kidney disease. J Clin Endocrinol Metab 2021; 106: 397–409, DOI: 10.1210/clinem/dgaa851.
101. Gu Z, Yang X, Wang Y, Gao J. Effects of denosumab on bone mineral density and bone metabolism in patients with end-stage renal disease: a systematic review and meta-analysis. Hemodial Int 2023; 27: 352–363, DOI: 10.1111/hdi.13098.
102. Tang T, Wan B, Zhang A, et al. Efficacy of denosumab in treatment of osteoporosis in patients with rheumatoid arthritis: a meta-analysis of randomized controlled trial. BMC Musculoskelet Disord 2025; 26: 450, DOI: 10.1186/s12891-025-08688-8.
103. Lau AN, Wong-Pack M, Rodjanapiches R, et al. Occurrence of serious infection in patients with rheumatoid arthritis treated with biologics and denosumab observed in a clinical setting. J Rheumatol 2018; 45: 170–176, DOI: 10.3899/jrheum.161270.
104. Bruni C, Cigolini C, Tesei G, et al. Combination of denosumab and biologic DMARDs in inflammatory muscle-skeletal diseases and connective tissue diseases. Eur J Rheumatol 2021; 8: 190–195, DOI: 10.5152/eurjrheum.2020.21162.
105. Mısırcı S, Ekin A, Yağız B, et al. Does the use of denosumab in combination with bDMARDs or tsDMARDs increase the risk of infection in patients with osteoporosis and inflammatory rheumatic diseases? J Clin Med 2025; 14: 6090, DOI: 10.3390/jcm14176090.
106. Ha J, Lee YJ, Kim J, et al. Long-term efficacy and safety of denosumab: insights beyond 10 years of use. Endocrinol Metab (Seoul) 2025; 40: 47–56, DOI: 10.3803/EnM.2024.2125.
107. Ferrari S, Lewiecki EM, Butler PW, et al. Favorable skeletal benefit/risk of long-term denosumab therapy: a virtual-twin analysis of fractures prevented relative to skeletal safety events observed. Bone 2020; 134: 115287, DOI: 10.1016/j.bone.2020.115287.
108. Tsourdi E, Zillikens MC, Meier C, et al. Fracture risk and management of discontinuation of denosumab therapy: a systematic review and position statement by ECTS. J Clin

Endocrinol Metab 2021; 106: 264–281, DOI: 10.1210/clinem/dgaa756.
109. Lin L, Ren Y, Wang X, Yao Q. Effects of bisphosphonates and denosumab on dental implants: a systematic review with meta-analysis. Oral Dis 2025; 31: 2835–2847, DOI: 10.1111/odi.15373.
110. Miller SA, St Onge EL, Whalen KL. Romosozumab: a novel agent in the treatment for postmenopausal osteoporosis. J Pharm Technol 2021; 37: 45–52, DOI: 10.1177/8755122520967632.
111. Hu M, Zhang Y, Guo J, et al. Meta-analysis of the effects of denosumab and romosozumab on bone mineral density and turnover markers in patients with osteoporosis. Front Endocrinol (Lausanne) 2023; 14: 1188969, DOI: 10.3389/fendo.2023.1188969.
112. Saag KG, Petersen J, Brandi ML, et al. Romosozumab or alendronate for fracture prevention in women with osteoporosis. N Engl J Med 2017; 377: 1417–1427, DOI: 10.1056/NEJMoa1708322.
113. Cosman F, Crittenden DB, Adachi JD, et al. Romosozumab treatment in postmenopausal women with osteoporosis. N Engl J Med 2016; 375: 1532–1543, DOI: 10.1056/NEJMoa1607948.
114. Kobayakawa T. Sequential and combination therapy with romosozumab. J Bone Miner Metab 2025; 43: 10–17, DOI: 10.1007/s00774-025-01590-2.
115. Mochizuki T, Yano K, Ikari K, Okazaki K. Effects of romosozumab or denosumab treatment on the bone mineral density and disease activity for 6 months in patients with rheumatoid arthritis with severe osteoporosis: an open-label, randomized, pilot study. Osteoporos Sarcopenia 2021; 7: 110–114, DOI: 10.1016/j.afos.2021.08.001.
116. Mochizuki T, Yano K, Ikari K, et al. Comparison of romosozumab versus denosumab treatment on bone mineral density after 1 year in rheumatoid arthritis patients with severe osteoporosis: a randomized clinical pilot study. Mod Rheumatol 2023; 33: 490–495, DOI: 10.1093/mr/roac059.
117. Kobayakawa T, Miyazaki A, Kanayama Y, et al. Comparable efficacy of denosumab and romosozumab in patients with rheumatoid arthritis receiving glucocorticoid administration. Mod Rheumatol 2023; 33: 96–103, DOI: 10.1093/mr/roac014.
118. Liu Y, Liu X, Wu Y, Luo T. Efficacy and safety of sequential therapy for primary osteoporosis with bone formation promoters followed by bone resorption inhibitors: a meta-analysis. J Orthop Surg Res 2025; 20: 147, DOI: 10.1186/s13018-025-05545-1.
119. Roumpou A, Palermo A, Tournis S, et al. Bone in parathyroid diseases revisited: evidence from epidemiological, surgical and new drug outcomes. Endocr Rev 2025; 46: 576–620, DOI: 10.1210/endrev/bnaf010.
120. Díez-Pérez A, Marin F, Eriksen EF, et al. Effects of teriparatide on hip and upper limb fractures in patients with osteoporosis: a systematic review and meta-analysis. Bone 2019; 120: 1–8, DOI: 10.1016/j.bone.2018.09.020.
121. Akhter S, Qureshi AR, El-Khechen HA, et al. The efficacy of teriparatide on lumbar spine bone mineral density, vertebral fracture incidence and pain in post-menopausal osteoporotic patients: a systematic review and meta-analysis. Bone Rep 2020; 13: 100728, DOI: 10.1016/j.bonr.2020.100728.
122. Beaudart C, Veronese N, Douxfils J, et al. PTH1 receptor agonists for fracture risk: a systematic review and network meta-analysis. Osteoporos Int 2025; 36: 951–967, DOI: 10.1007/s00198-025-07440-1.
123. Ramchand SK, Leder BZ. Sequential therapy for the long-term treatment of postmenopausal osteoporosis. J Clin Endocrinol Metab 2024; 109: 303–311, DOI: 10.1210/clinem/dgad496.
124. Ebina K, Hirao M, Hashimoto J, et al. Assessment of the effects of switching oral bisphosphonates to denosumab or daily teriparatide in patients with rheumatoid arthritis. J Bone Miner Metab 2018; 36: 478–487, DOI: 10.1007/s00774-017-0861-4.
125. Kaneko T, Okamura K, Yonemoto Y, et al. Short-term daily teriparatide in patients with rheumatoid arthritis. Mod Rheumatol 2018; 28: 468–473, DOI: 10.1080/14397595.2017.1362093.
126. Mineta K, Nishisho T, Okada M, et al. Real-world safety and effectiveness of romosozumab following daily or weekly administration of teriparatide in primary and secondary osteoporosis. Bone 2025; 193: 117392, DOI: 10.1016/j.bone.2025.117392.
127. Kobayakawa T, Kanayama Y, Hirano Y, et al. Therapy with transitions from one bone-forming agent to another: a retrospective cohort study on teriparatide and romosozumab. JBMR Plus 2024; 8: ziae131, DOI: 10.1093/jbmrpl/ziae131.
128. Ebina K, Kobayakawa T, Etani Y, et al. Impact of prior teriparatide treatment on the effectiveness of romosozumab in patients with postmenopausal osteoporosis: a case-control study. Bone 2025; 193: 117389, DOI: 10.1016/j.bone.2025.117389.
129. Ghielmetti A, Grassi G, Zampogna M, et al. Sequential treatment for osteoporosis after teriparatide: a real-life long-term comparison between zoledronic acid and denosumab. J Clin Med 2025; 14: 6360, DOI: 10.3390/jcm14186360.
130. The 2022 Hormone Therapy Position Statement of The North American Menopause Society Advisory Panel. The 2022 hormone therapy position statement of The North American Menopause Society. Menopause 2022; 29: 767–794, DOI: 10.1097/GME.0000000000002028.
131. Cauley JA, Robbins J, Chen Z, et al. Effects of estrogen plus progestin on risk of fracture and bone mineral density: the Women's Health Initiative randomized trial. JAMA 2003; 290: 1729–1738, DOI: 10.1001/jama.290.13.1729.
132. The Writing Group for the PEPI Trial. Effects of hormone therapy on bone mineral density: results from the postmenopausal estrogen/progestin interventions (PEPI) trial. JAMA 1996; 276: 1389–1396, DOI: 10.1001/jama.1996.03540170033029.
133. Bofill Rodriguez M, Yong LN, Mirkov S, et al. Long-term hormone therapy for perimenopausal and postmenopausal women. Cochrane Database Syst Rev 2025; 11: CD004143, DOI: 10.1002/14651858.CD004143.pub6.
134. Anagnostis P, Divaris E, Bosdou JK, et al. Antiosteoporosis therapy after discontinuation of menopausal hormone therapy: a systematic review. Hormones (Athens) 2024; 23: 339–344, DOI: 10.1007/s42000-024-00526-1.
135. Ascott-Evans BH, Guanabens N, Kivinen S, et al. Alendronate prevents loss of bone density associated with discontinuation of hormone replacement therapy: a randomized controlled trial. Arch Intern Med 2003; 163: 789–794, DOI: 10.1001/archinte.163.7.789.

136. Vinogradova Y, Iyen B, Masud T, et al. Discontinuation of menopausal hormone therapy and risk of fracture: nested case-control studies using routinely collected primary care data. Lancet Healthy Longev 2025; 6: 100729, DOI: 10.1016/j.lanhl.2025.100729.
137. Cho SK, Kim H, Lee J, et al. Effectiveness of bazedoxifene in preventing glucocorticoid-induced bone loss in rheumatoid arthritis patients. Arthritis Res Ther 2021; 23: 176, DOI: 10.1186/s13075-021-02564-1.
138. Cranney A, Tugwell P, Zytaruk N, et al. Meta-analyses of therapies for postmenopausal osteoporosis. IV. Meta-analysis of raloxifene for the prevention and treatment of postmenopausal osteoporosis. Endocr Rev 2002; 23: 524–528, DOI: 10.1210/er.2001-4002.
139. Ettinger B, Black DM, Mitlak BH, et al. Reduction of vertebral fracture risk in postmenopausal women with osteoporosis treated with raloxifene: results from a 3-year randomized clinical trial. JAMA 1999; 282: 637–645, DOI: 10.1001/jama.282.7.637.
140. Siris ES, Harris ST, Eastell R, et al. Skeletal effects of raloxifene after 8 years: results from the continuing outcomes relevant to Evista (CORE) study. J Bone Miner Res 2005; 20: 1514–1524, DOI: 10.1359/JBMR.050509.
141. Delmas PD, Genant HK, Crans GG, et al. Severity of prevalent vertebral fractures and the risk of subsequent vertebral and nonvertebral fractures: results from the MORE trial. Bone 2003; 33: 522–532, DOI: 10.1016/S8756-3282(03)00241-2.
142. Visvanathan K, Chlebowski RT, Hurley P, et al. American Society of Clinical Oncology clinical practice guideline update on the use of pharmacologic interventions including tamoxifen, raloxifene, and aromatase inhibition for breast cancer risk reduction. J Clin Oncol 2009; 27: 3235–3258, DOI: 10.1200/JCO.2008.20.5179.
143. Lippuner K, Buchard PA, De Geyter C, et al. Recommendations for raloxifene use in daily clinical practice in the Swiss setting. Eur Spine J 2012; 21: 2407–2417, DOI: 10.1007/s00586-012-2404-y.
144. Yang F, Li N, Gaman MA, Wang N. Raloxifene has favorable effects on the lipid profile in women explaining its beneficial effect on cardiovascular risk: a meta-analysis of randomized controlled trials. Pharmacol Res 2021; 166: 105512, DOI: 10.1016/j.phrs.2021.105512.
145. Ferretti G, Bacchetti T, Simental-Mendía LE, et al. Raloxifene lowers plasma lipoprotein(a) concentrations: a systematic review and meta-analysis of randomized placebo-controlled trials. Cardiovasc Drugs Ther 2017; 31: 197–208, DOI: 10.1007/s10557-017-6721-6.
146. Martino S, Cauley JA, Barrett-Connor E, et al. Continuing outcomes relevant to Evista: breast cancer incidence in postmenopausal osteoporotic women in a randomized trial of raloxifene. J Natl Cancer Inst 2004; 96: 1751–1761, DOI: 10.1093/jnci/djh319.
147. Public statement on Protelos: withdrawal of the marketing authorisation in the European Union. Available at: https://www.ema.europa.eu/en/documents/public-statement/public-statement-protelos-withdrawal-marketing-authorisation-european-union_en.pdf (Access: 21.03.2026).
148. European Medicines Agency recommends limiting long-term use of calcitonin medicines. Available at: https://www.ema.europa.eu/en/news/european-medicines-agency-recommends-limiting-long-term-use-calcitonin-medicines (Access: 21.03.2026).
149. Pepe J, Body JJ, Hadji P, et al. Osteoporosis in premenopausal women: a clinical narrative review by the ECTS and the IOF. J Clin Endocrinol Metab 2020; 105: dgaa306, DOI: 10.1210/clinem/dgaa306.
150. Herath M, Cohen A, Ebeling PR, Milat F. Dilemmas in the management of osteoporosis in younger adults. JBMR Plus 2022; 6: e10594, DOI: 10.1002/jbm4.10594.
151. Shane E, Shiau S, Recker RR, et al. Denosumab after teriparatide in premenopausal women with idiopathic osteoporosis. J Clin Endocrinol Metab 2022; 107: e1528–e1540, DOI: 10.1210/clinem/dgab850.
152 Agarwal S, Shane E, Lang T, et al. Spine volumetric BMD and strength in premenopausal idiopathic osteoporosis: effect of teriparatide followed by denosumab. J Clin Endocrinol Metab 2022; 107: e2690–e2701, DOI: 10.1210/clinem/dgac232.
153. Fujimoto K, Maki N, Hashiba D, et al. Effect of romosozumab in premenopausal women with severe osteoporosis and anorexia nervosa. Osteoporos Sarcopenia 2023; 9: 137–141, DOI: 10.1016/j.afos.2023.10.001.
154. Ciancia S, van Rijn RR, Högler W, et al. Osteoporosis in children and adolescents: when to suspect and how to diagnose it. Eur J Pediatr 2022; 181: 2549–2561, DOI: 10.1007/s00431-022-04455-2.
155. Galindo-Zavala R, Bou-Torrent R, Magallares-López B, et al. Expert panel consensus recommendations for diagnosis and treatment of secondary osteoporosis in children. Pediatr Rheumatol Online J 2020; 18: 20, DOI: 10.1186/s12969-020-0411-9.
156. Ward LM. A practical guide to the diagnosis and management of osteoporosis in childhood and adolescence. Front Endocrinol (Lausanne) 2024; 14: 1266986, DOI: 10.3389/fendo.2023.1266986.
157. Ciancia S, Högler W, Sakkers RJB, et al. Osteoporosis in children and adolescents: how to treat and monitor? Eur J Pediatr 2023; 182: 501–511, DOI: 10.1007/s00431-022-04743-x.
158. Zhao H, Ding Y, Yang J, et al. Efficacy and safety of bisphosphonates on childhood osteoporosis secondary to chronic illness or its treatment: a meta-analysis. Ther Adv Chronic Dis 2022; 13: 20406223221129163, DOI: 10.1177/20406223221129163.