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CLINICAL GUIDELINE · PEDIATRIC COMPLEX CARE PLATFORM

Bone Health in Children with Medical Complexity

Prevention, assessment, investigation, diagnosis and management of impaired bone health and osteoporosis

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Intended for healthcare professionals as a clinical reference. Apply with clinical judgment and in line with local protocols.

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1 Scope

This guideline provides a standardized approach to the **prevention, assessment, investigation, diagnosis and management** of impaired bone health and osteoporosis in children and adolescents with medical complexity (CMC), particularly those with **reduced mobility, nutritional deficiencies, chronic systemic diseases**, or exposure to **medications affecting bone health**.

2 Definitions

Fragility fracture	A fracture following **low-energy trauma** that would not ordinarily cause a fracture in healthy bone.
Clinically significant fracture history	• **≥2** long-bone fractures by age **10 years**; or • **≥3** long-bone fractures by age **19 years**.
Low bone mineral density (BMD)	DXA BMD **Z-score ≤−2.0**, adjusted for age, sex and body size as appropriate.
Pediatric osteoporosis	Diagnosed when either: • **≥1 nontraumatic vertebral compression fracture**, in the absence of local disease or high-energy trauma; or • **Clinically significant fracture history** and BMD **Z-score ≤−2.0**.
Vertebral compression fracture	Vertebral height loss **≥20%**, endplate deformity, or cortical buckling on lateral spine imaging.

Important: a DXA Z-score above −2.0 does **not** exclude skeletal fragility or osteoporosis.

3 Risk Factors

Reduced mechanical loading
Non-ambulatory status, prolonged immobilization, neuromuscular disorders.

Nutritional status
Malnutrition and inadequate calcium or vitamin D intake.

Low lean body mass
Reduced muscle mass and associated mechanical loading on bone.

Endocrine
Delayed puberty, hypogonadism, growth hormone deficiency.

Chronic diseases
Renal, gastrointestinal, inflammatory and metabolic disorders.

Medications
Prolonged systemic glucocorticoids, selected antiseizure medications and other osteotoxic therapies.

Previous fragility fractures

4 Clinical Assessment

History

- Previous fractures: number, site, mechanism and healing.
- Bone or back pain, unexplained irritability, or reduced mobility.
- Nutritional intake, calcium/vitamin D supplementation and feeding difficulties.
- Mobility, weight-bearing activities and physiotherapy.
- Medication exposure and relevant chronic conditions.
- Growth, puberty and menstrual history.

Examination

- Growth parameters and nutritional status.
- Pubertal development.
- Skeletal deformities, spinal tenderness and signs of previous fractures.
- Mobility, muscle mass and joint contractures.

★ **Clinical pearl:** in nonverbal children, unexplained pain, irritability, or reduced tolerance of handling may indicate an **occult fracture**.

5 Investigations

5.1 Laboratory investigations

For suspected metabolic bone disease, fragility fractures, or clinically significant risk factors:

- **Calcium (albumin-adjusted or ionized)**
- **Phosphate**
- **Alkaline phosphatase (ALP)**
- **25-hydroxyvitamin D**
- **Parathyroid hormone (PTH)**
- **Creatinine and renal function**
- **Magnesium, when indicated**

Additional investigations should be guided by suspected underlying conditions.

5.2 Imaging

Plain radiographs	• Targeted X-rays for suspected fractures. • **Lateral thoracolumbar spine imaging:** consider when vertebral fractures are suspected (e.g., new back pain or unexplained height loss), in selected high-risk children, or following a significant decline in BMD Z-score.
DXA scan	**INDICATIONS** • Consider in children with **fragility fractures** or **significant risk factors** for impaired bone health, when results may influence clinical management. **PREFERRED SITES** • **Lumbar spine and total body less head (TBLH):** standard pediatric DXA sites. • **Lateral distal femur (LDF):** particularly useful in non-ambulatory children, especially those with cerebral palsy or positioning difficulties, when appropriate reference data are available. **INTERPRETATION** • Adjusted for age, sex and body size as appropriate. • **Z-score ≤ −2.0:** low BMD for age. • A Z-score above −2.0 does **not** exclude skeletal fragility or osteoporosis. **FOLLOW-UP** • Repeat DXA generally every **12–24 months** when results may influence management, using comparable sites and methodology. • Consider consultation with a pediatric endocrinologist or bone-health specialist to guide timing and interpretation.

6 Prevention and Management

6.1 General preventive measures

Nutrition	Ensure adequate protein, calcium and vitamin D intake; address malnutrition.
Mobility	Promote safe weight-bearing activities and physiotherapy, where feasible.
Growth and puberty	Monitor growth and pubertal development; address abnormalities.
Medications	Review and minimize exposure to medications adversely affecting bone health, when clinically appropriate.
Safe handling	Educate caregivers on appropriate positioning and transfers to minimize fracture risk.

6.2 Calcium

Recommended daily **elemental calcium** intake (diet plus supplements):

Age	Recommended intake (mg/day)	Upper limit (mg/day)
0–6 months	200	Not established
7–12 months	260	Not established
1–3 years	700	2,500
4–8 years	1,000	2,500
9–18 years	1,300	3,000

Values represent **total daily** elemental calcium intake from diet, enteral formulas and supplements. The upper limit is a safety threshold, not a treatment target.

Calcium supplementation

- ✓ Prioritize dietary and enteral sources of calcium.
- ✓ Supplement when intake is below age-appropriate requirements.
- ✓ Calculate supplementation based on the difference between actual intake and recommended daily intake.
- ✓ Divide larger supplemental doses into multiple administrations (generally **≤500 mg elemental calcium per dose**) to optimize absorption.
- ✓ **Monitoring:** consider serum calcium measurement every **6–12 months** as part of nutritional blood work in at-risk children.

! **Special consideration:** children with chronic kidney disease, hypercalcemia, hypercalciuria, or nephrolithiasis require **individualized** calcium management.

6.3 Vitamin D

6.3.1 Maintenance vitamin D

Age	Routine intake (IU/day)
0–12 months	400
1–18 years	600

High-risk children (e.g., non-ambulatory children with cerebral palsy or those on long-term antiseizure medications): consider **800–1,000 IU/day**, accounting for intake from enteral formulas and other supplements.

6.3.2 25-OH vitamin D

- A level **≥50 nmol/L** is generally adequate for most children.
- Higher individualized targets may be considered in selected metabolic bone disorders.
- **Monitoring:** assess 25-OH vitamin D every **6–12 months** as part of nutritional and bone-health monitoring in at-risk children, or earlier when clinically indicated.

6.3.3 Treatment of nutritional vitamin D deficiency

Age	Oral vitamin D dose	Duration
Under 1 year	2,000 IU/day	6–12 weeks
1–18 years	2,000–6,000 IU/day	6–12 weeks

Dose selection	Individualize according to severity of deficiency, clinical presentation and underlying risk factors.
Severe deficiency or malabsorption	Higher doses or prolonged treatment may be required under specialist supervision.
Monitoring	Reassess 25-OH vitamin D and calcium after 6–12 weeks; consider phosphate, ALP and PTH when indicated.
Maintenance	Continue age-appropriate vitamin D supplementation after correction.
Calcium	Ensure adequate calcium intake throughout treatment.

Important: the upper end of these ranges is intended for severe deficiency or nutritional rickets, not routine treatment of uncomplicated vitamin D deficiency. **Confirmed nutritional rickets** requires a specific treatment protocol, generally for at least **12 weeks**, with adequate calcium intake.

6.4 Bisphosphonates

Consider specialist-directed treatment for

- Vertebral compression fractures.
- Recurrent clinically significant fragility fractures.
- Established osteoporosis with ongoing fracture risk.

Common agents: IV pamidronate or IV zoledronic acid.

Before treatment

- ✓ Assess calcium, phosphate, 25-OH vitamin D and renal function.
- ✓ Consider dental evaluation when clinically indicated.

Adverse effects

- **Acute-phase reaction:** fever, myalgia, bone pain and nausea/vomiting, typically within 24–48 hours of the first infusion. Treat supportively with analgesics, antipyretics and antiemetics as needed.
- Transient hypocalcemia or hypophosphatemia.
- Rare longer-term skeletal or dental complications.

Specialist management: initiation, dosing, administration and monitoring should be directed by a pediatric endocrinologist or bone-health specialist.

7 Monitoring and Follow-Up

For children at increased risk of impaired bone health:

Clinical assessment	**Every 3–6 months**	Review fracture history, bone pain, mobility, nutrition, growth, puberty and medication exposure.
Laboratory monitoring	**Every 6–12 months**	Based on underlying risk factors, identified deficiencies and treatment.
DXA scan	**Every 1–2 years**	Repeat when clinically indicated, using comparable sites and methodology. Consider specialist consultation to guide frequency and interpretation.
Spinal imaging	**Annually (selected)**	Consider annual lateral spine imaging in selected high-risk children, or earlier if vertebral fracture is suspected (e.g., new back pain or unexplained height loss) or BMD Z-score declines significantly.
Bisphosphonate therapy	**Individualized**	Intervals, duration and monitoring directed by the pediatric endocrinologist or bone-health specialist.

Monitoring frequency should be individualized according to underlying disease, fracture risk and treatment.

8 Indications for Specialist Referral

Pediatric Endocrinology / Bone Health

- Vertebral compression fracture.
- Recurrent or unexplained fragility fractures.
- Suspected primary bone disease.
- Low BMD with clinically significant fracture risk.
- Persistent mineral abnormalities or consideration of bisphosphonates.

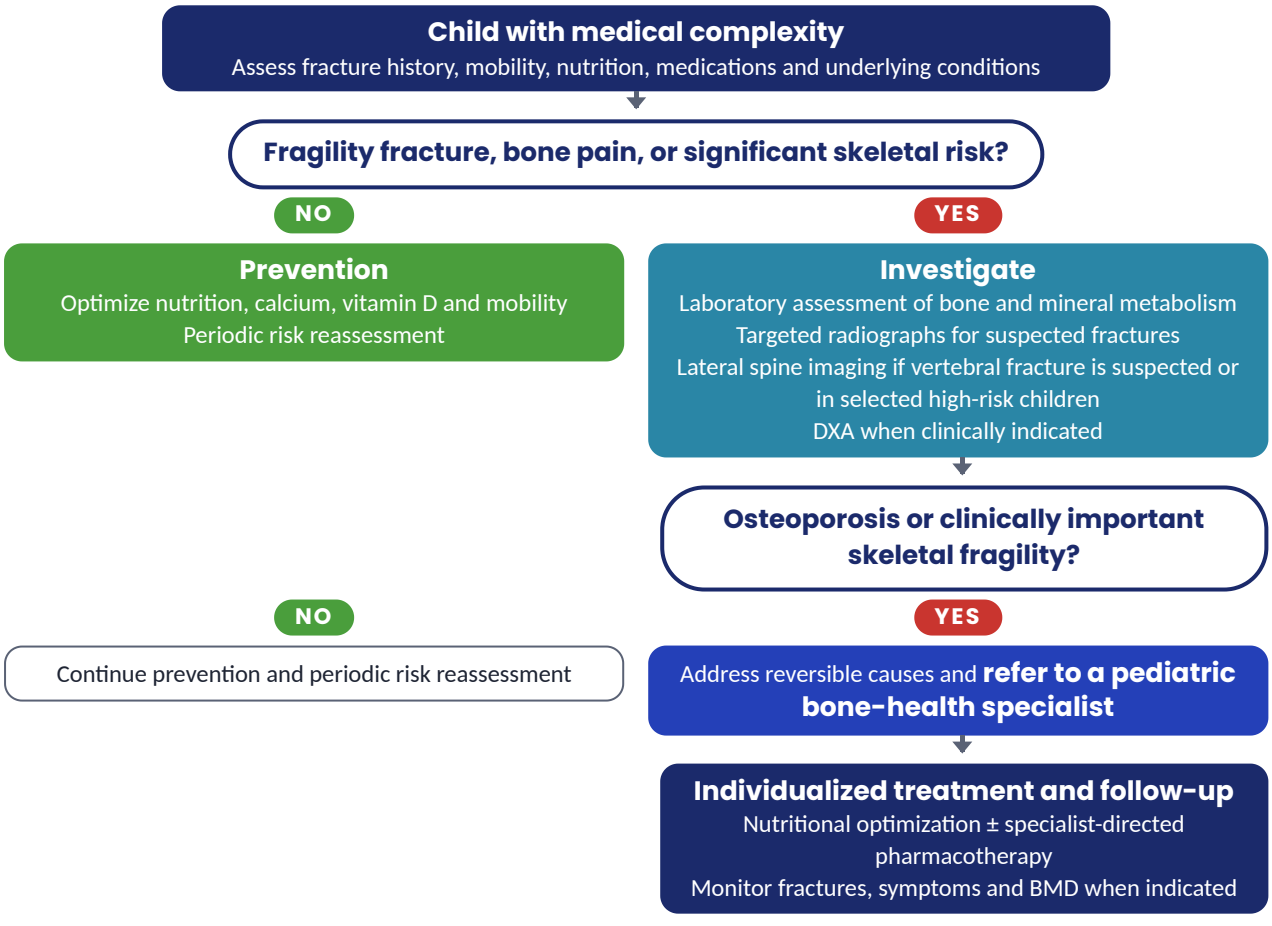
Pediatric Orthopedics

- Suspected or confirmed fracture requiring orthopedic assessment.
- Significant skeletal deformity or fracture-related complications.

Dietitian / Physiotherapy

- Inadequate nutritional intake or deficiencies.
- Reduced mobility requiring individualized weight-bearing and rehabilitation plans.

9 Clinical Algorithm



10 References

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