INTRODUCTION —

Bow-legs (genu varum) is an angular deformity at the knee where the apex of the deformity points away from the midline (figure 1). Knock-knees (genu valgum) are an angular deformity at the knee where the apex of the deformity points toward the midline (figure 1).

Bow-legs and knock-knees are among the most common musculoskeletal anatomic variations encountered by pediatric primary care providers and a common reason for referral to a pediatric orthopedic surgeon. However, most children with bow-legs or knock-knees have variations of normal lower-extremity development that can be monitored by the primary care provider.

An understanding of the normal physiologic development of the lower extremity is essential in differentiating physiologic from pathologic alignment. Pathologic causes of bow-legs include Blount disease, nutritional rickets and other metabolic bone diseases, skeletal dysplasia, infection, trauma, and neoplasia. Unlike physiologic bowing, these conditions generally do not improve over time and may require treatment with bracing or surgery.

This topic will provide an overview of normal physiologic alignment of the lower extremity, physiologic and pathologic causes of bowing, and an approach to the child with bow-legs.

NORMAL PHYSIOLOGIC ALIGNMENT

— An understanding of normal development of the lower extremity is essential to differentiation of physiologic from pathologic deformities.

Lower-extremity alignment goes through a predictable progression from varus (bow-legs) to valgus (knock-knees) over the first seven years of life [1]. There is a wide range of normal values [1,2].

● At birth, normal alignment is varus.
● As the child begins to stand and walk, the amount of varus often increases. Children who walk at an early age may have greater varus alignment.

● Around 18 to 24 months of age, alignment should be neutral.

● After 24 months, alignment should progress to valgus until it reaches a maximum at four years.

● After age four years, valgus alignment should decrease toward physiologic adult alignment of slight valgus to neutral.

● By age seven years, a child usually has reached his or her adult lower-extremity alignment.

CAUSES OF BOW-LEGS — Causes of bow-legs include physiologic bowing, Blount disease, nutritional rickets and other metabolic bone diseases, skeletal dysplasias, trauma, infection, and neoplasia.
Physiologic varus — The normal alignment of the lower extremity from birth until 18 to 24 months of age is varus. The majority of young children with bowed legs have physiologic bowing, defined as varus deformity with a tibiofemoral angle that is within two standard deviations from the mean for age. (See 'Normal physiologic alignment' above.)

Characteristic features of physiologic bowing include

- Age between birth and two years
● Bilateral and relatively symmetric deformities

● Bowing of both femurs and tibias

● Normal stature (ie, within two standard deviations of the mean for age and sex)

● No lateral thrust with ambulation; a lateral thrust is a brief lateral knee-joint protrusion during the stance phase of gait that suggests incompetence of the knee ligaments with increased risk of progression (figure 4) [5,6]

Physiologic bowing often is associated with internal tibial torsion, which accentuates the apparent genu varum [4].

**Physiologic bow-legs**

Examination of the child with physiologic bowing shows symmetric bowing throughout the tibia and internal tibial torsion, which is often more noticeable with walking.

Although it is not necessary to obtain radiographs in children with physiologic bowing, radiographic features of physiologic bowing include (image 1) [2,7]:

- [Image]

[5,6]

[4]

[2,7]
Tibial metaphyseal-diaphyseal (MD) angle of ≤11°

Femur MD angles greater than tibial MD angles (ratio of femur MD angle:tibial MD angle >1)

Pathologic varus — Pathologic varus may be caused by Blount disease, systemic disorders (eg, nutritional rickets and other metabolic bone diseases), skeletal dysplasia, or asymmetric growth (eg, following unilateral trauma, infection, or neoplasia) (table 1) [4,5].

Clinical and radiographic features distinguish physiologic from pathologic varus [2]. Clues to pathologic varus include short stature, lateral thrust (figure 4), asymmetry, and progression rather than improvement between birth and two years (table 2) [5-8].

### Clues to pathologic causes of bow-legs

<table>
<thead>
<tr>
<th>Clue</th>
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<tr>
<td>Severe bowing (&gt;6 cm between the femoral condyles with patella facing forward and medial malleoli together)</td>
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<td>Progressive bowing</td>
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<td>Persistent bowing (after 3 years)</td>
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<td>Short stature</td>
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<td>History of metabolic disease, lower-extremity fracture, infection, or tumor</td>
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Blount disease — Blount disease is a pathologic varus deformity that results from disruption of normal cartilage growth at the medial aspect of the proximal tibial physis (image 2) [9]. This may cause severe varus deformity, leg length discrepancy, and articular incongruity.

There are two types of Blount disease: infantile and adolescent. Infantile Blount disease typically is diagnosed before four years of age and must be distinguished from physiologic varus; it is usually bilateral (80 percent of cases) and typically worsens after walking has begun [5,7]. Adolescent Blount disease is diagnosed later in childhood and may be unilateral or bilateral [10]. Risk factors for Blount disease include obesity, African-American ethnicity, and early walking [10]. (See "Comorbidities and complications of obesity in children and adolescents", section on 'Tibia vara (Blount disease)'.)

Physical examination in children with Blount disease may demonstrate asymmetric angular alignment of the lower extremities, focal angulation at the proximal tibia, and lateral thrust (figure 4) during the stance phase of ambulation. Patients with these characteristics should undergo radiographic examination. (See 'Radiographs' below.)

Radiographic features of Blount disease include varus deformity of the proximal tibia with medial beaking and downward slope of the proximal tibial metaphysis (image 2). In addition, the proximal tibial metaphyseal-diaphyseal (MD) angle is usually >16° (image 3), although this finding is not diagnostic [2,11,12]. The femur MD angle is less than the tibial MD angle (ratio of femur MD angle:tibial MD angle
The tibial metaphyseal-diaphyseal angle is measured on an anteroposterior standing radiograph of the knee as follows: 1) draw a line along the longitudinal axis of the tibia (line 1); 2) draw a line through the lateral peaks of the proximal tibial metaphysis (line 2); 3) draw a line perpendicular to line 1 at the intersection of lines 1 and 2 (line 3); 3) measure the angle between lines 2 and 3 (the tibial metaphyseal-diaphyseal angle). A tibial metaphyseal-diaphyseal angle ≤11° suggests physiologic rather than pathologic bowing. In this patient with Blount disease, the tibial metaphyseal-diaphyseal angle is approximately 18°.

The treatment of Blount disease depends upon the age of the child and the severity of the deformity. Patients with infantile Blount disease may be treated with braces to unload medial compressive forces [5,13]. Brace treatment should be started by three years of age [13]. In observational studies, brace therapy is successful in 50 to 80 percent of patients [14]. If the deformity does not resolve with bracing, surgical therapies include guided growth through hemiepiphysiodesis (arrest of the growth plate on the apical side of the deformity) or tibial osteotomy and realignment [14,15]. Surgical intervention for infantile Blount disease should be performed before four years of age to reduce the risk of recurrence [14]. Bracing is ineffective in the treatment of adolescent Blount disease. Surgical intervention with hemiepiphysiodesis or tibial osteotomy is the mainstay of treatment.

Rickets — Rickets is a disorder characterized by deficient bone mineralization (metabolic bone disease). When it has onset before 18 to 24 months of age (eg, nutritional vitamin D deficiency, X-linked hypophosphatemic rickets, Fanconi syndrome) it is associated with genu varum (picture 2); when it has later onset (ie, during the valgus stage of development around age four years), it is associated with knock-knees [5]. (See "Etiology and treatment of calcipenic rickets in children" and "Hereditary hypophosphatemic rickets and tumor-induced osteomalacia").
Patients with rickets usually are of short stature (<10th percentile) and have bilateral, symmetric nonphysiologic bowing of the femurs and tibias [7]. Laboratory abnormalities vary depending upon the underlying disorder. In severe cases, radiographs may show diminished bone density, widened and cupped physes, and flared metaphyses (image 4) [2]. The absence of these findings on radiographs does not preclude a less severe degree of metabolic bone disease. Rickets deformity may improve with medical treatment. Surgical intervention should be delayed until adequate medical control is achieved [16]. (See "Overview of rickets in children".)

Skeletal dysplasia — Skeletal dysplasia (eg, achondroplasia, pseudoachondroplasia, metaphyseal chondrodysplasia) is another cause of bilateral, symmetric bowed legs [17]. Additional features of skeletal dysplasia may include short stature (<5th percentile) and characteristic physical features [2]. The clinical features vary depending upon the underlying disorder (table 1). Serum calcium and phosphorous concentrations typically are normal in children with skeletal dysplasias [7]. Radiographic features of skeletal dysplasia vary with the site of involvement, which may be principally epiphyseal, physeal, metaphyseal, or diaphyseal, or may involve multiple sites. A skeletal survey, which includes the skull and spine, may be needed to assess a child with suspected skeletal dysplasia.

Asymmetric growth — Bow-legs also may be caused by asymmetric growth arrest or overgrowth of the distal femur and/or proximal tibia (secondary to infection, fracture, or neoplasia) [3-6]. Such deformities are almost always unilateral.

CLINICAL PRESENTATION — Presenting complaints for children with bow-legs may include concerns about appearance of the child's legs, excessive falling, and/or in-toeing (which is often associated with bow-legs).

EVALUATION

— The physical examination is the most important component of the evaluation of the child with bow-legs. Radiographs are necessary in a minority of cases. (See 'Radiographs' below.)

History — Important aspects of the history in a child with bow-legs include [5-7,15,18]:

● Growth and development
● Onset (ie, before or after birth? Before or after walking?)
● Progression (physiologic varus improves with growth; pathologic varus worsens with growth)
● Associated complaints (pain, limp, tripping, falling, in-toeing)
● Family history (parents or siblings with similar appearance, short stature, rickets, skeletal dysplasia)
● Previous treatment (if any) and treatment response
● Dietary and vitamin intake (particularly calcium and vitamin D)
• Sunlight exposure

• History of infection, trauma, or fracture (that may have caused asymmetric growth retardation or stimulation)

It is also important to ascertain the parents' perceptions of the deformity and concerns regarding gait, appearance, and function.

Physical examination — Important aspects of the physical examination of the child with lower-extremity malalignment include [5-7,15,18]:

• Length/height – The child's length or height should be plotted on the standardized growth curve ((figure 5 and figure 6) [for boys] and (figure 7 and figure 8) [for girls]). Lower-extremity malalignment and length/height less than the 3rd percentile are potential clues to a pathologic condition (eg, rickets, skeletal dysplasia) [19]. Less severe short stature (eg, 10th or 25th percentile) may be cause for concern if the child has other manifestations of a pathologic condition associated with bow-legs (table 1). (See 'Pathologic varus' above.)

• Weight – The child's weight should be measured and body mass index calculated ((calculator 1) [for boys] and (calculator 2) [for girls]). Obesity is a risk factor for adolescent Blount disease. (See 'Blount disease' above and "Clinical evaluation of the obese child and adolescent".)

• Focused examination of the lower extremities – Focused examination of the lower extremities in young children may be easier if performed with the child sitting on the parent's lap.

With the child in the seated position, the knees should be extended and the legs rotated so that the patellas are pointed straight ahead. This maneuver is necessary to accurately estimate lower-extremity angular alignment because it removes any apparent varus or valgus that may be caused by tibial torsion or femoral anteversion (picture 3). With the legs held in this position, a gross estimate of the amount of varus can be measured. Greater than 6 cm between the femoral condyles is considered abnormal at any age [20]. This measurement provides a reproducible, objective, nonradiographic method of monitoring progression or improvement of the deformity over multiple clinic visits.

Additional components of the lower-extremity examination include [6]:

• Assessment of symmetry (asymmetry or unilateral involvement is suggestive of pathologic genu varum).

• Assessment of leg length (shortening of the legs may suggest skeletal dysplasia) (table 1). Leg-length discrepancy may indicate asymmetric physeal growth.

• Determination of the site of angulation: femur and tibia (physiologic bowing), knee (ligamentous hyperlaxity), proximal tibial metaphysis with acute medial angulation (Blount disease).

• Palpation of the epiphyses of the long bones (enlarged in nutritional rickets).
• Observation of gait – If the child is ambulatory, the child’s gait should be observed as the child walks toward and away from the examiner [2]. The foot progression and patellar progression angles should be noted. These angles describe the alignment of the foot and patella, respectively, as they relate to the direction that the patient is moving. For example, an internal foot progression angle describes a foot that points toward the midline as the patient walks forward. An external patellar progression angle describes a patella that points laterally as the patient walks forward.

The presence or absence of a lateral thrust during ambulation also should be noted. A lateral thrust is a brief lateral knee-joint protrusion during the stance phase of gait. It suggests incompetence of the knee ligaments and is a clue to pathologic bowing (figure 4) [5,6]. Lateral thrust may be characteristic of pathologic genu varum but is not seen in all cases.

Radiographs — Patients younger than three years and those who fit within the age-appropriate progression of varus (figure 2 and figure 3) rarely need radiographs. (See ‘Normal physiologic alignment’ above.)

• Indications – We suggest that radiographs be obtained in children with clinical features suggestive of pathologic varus (table 2) [2,6,15,18].

• Technique – Proper radiographic technique is essential to obtaining useful images. If possible, teleograms (the entire lower extremity from the hips to the feet of both lower extremities) should be obtained with the patient standing (image 5). The child should stand with the feet in a comfortable position, not squeezed together. Whether or not the child is standing, it is paramount that the patellas (not the feet) are pointing straight ahead. Otherwise, the amount of varus cannot be accurately assessed. Proper positioning permits serial comparison if necessary [2].

• Findings – Radiographs should be reviewed to [2,6,15]:

  • Determine which bones are affected (eg, femur, tibia, or both).

  • Determine which aspects of the bone are involved: bony diaphysis (as in osteogenesis imperfecta, trauma), metaphysis (skeletal dysplasia), physis or growth plate (rickets, skeletal dysplasia), epiphysis (Blount disease, skeletal dysplasia).

  • Determine the tibiofemoral angle (the angle between the long axis of the tibia and the long axis of the femur).

  • Determine the metaphyseal-diaphyseal (MD) angles of the distal femur and proximal tibia, which helps to identify the location and relative severity of the deformity [11,21,22]. A tibial MD angle >16º is suggestive of Blount disease. A femoral-tibial MD angle ratio >1 is suggestive of physiologic bowing, whereas a femoral-tibial MD angle ratio <1 suggests Blount disease. (See 'Blount disease' above.)

Additional evaluation — Additional evaluation may be necessary if radiographs are suggestive of rickets or skeletal dysplasia. The evaluation varies depending upon the suspected condition. (See "Overview of rickets in children".)
INDICATIONS FOR REFERRAL

— We suggest that children with clinical features suggestive of pathologic varus (table 2) be referred to an orthopedic surgeon or other specialist as indicated by the suspected underlying condition (eg, endocrinologist, geneticist) [15,18].

MANAGEMENT

Physiologic bowing — We recommend that patients with physiologic bowing (as defined above (see 'Physiologic varus' above)) be managed with observation and parental reassurance [5,15,18,23]. The natural history of physiologic bowing is spontaneous regression [1]. Patients should be followed at four-to six-month intervals to ensure resolution [2,8]. Orthotics, such as braces, splints, and shoe inserts, are ineffective, unnecessary, and may have negative psychosocial sequelae [2,15,23,24]. It is often helpful to emphasize that improvement in physiologic bowing takes longer than improvement in other conditions.

It is not uncommon to encounter families in which one of the parents was treated with braces or other devices for an unknown limb problem. It may be helpful to remind the family that the recommendation of observation and reassurance is based upon the current assessment of their child and that it is impossible to be certain exactly what condition the parent or other family member was treated for many years ago.

Pathologic bowing — The management of pathologic bowing depends upon the underlying problem. Medical therapy for the primary disease should be optimized if effective medical therapy is available (eg, rickets) [15]. Medical management may result in some improvement in lower-extremity alignment. (See "Overview of rickets in children" and "Etiology and treatment of calcipenic rickets in children" and 'Blount disease' above.)

Surgical therapy should be reserved for patients with residual deformity after medical optimization [8]. Surgical therapy for pathologic bowing may include guided growth through hemiepiphysiodesis (arrest of the growth plate on the apical side of the deformity) or tibial osteotomy.

OUTCOME — The natural history of physiologic bowing is spontaneous correction [1].

Pathologic bowing increases the load on the medial compartment of the knee, causing increased laxity of the lateral collateral ligament, lateral thrust, knee instability, and pain [25]. Long-term sequelae may include medial meniscal tears and increased risk of osteoarthritis.

SUMMARY AND RECOMMENDATIONS

● Lower-extremity alignment goes through a predictable progression from varus (bow-legs) to valgus (knock-knees) over the first seven years of life (figure 2 and figure 3). (See 'Normal physiologic alignment' above.)

● Most young children with bow-legs have physiologic bowing (varus). Physiologic varus is defined by a tibiofemoral angle within two standard deviations of the mean for age. Characteristic features of
physiologic varus include age between birth and 2 years, bilateral and relatively symmetric deformities, bowing of both femurs and tibias, normal stature, and no lateral thrust (figure 4) with ambulation. (See 'Physiologic varus' above.)

● Pathologic causes of bowing in young children may include Blount disease, nutritional rickets and other metabolic diseases, skeletal dysplasia, and asymmetric growth secondary to trauma, infection, or tumor (table 1). Clinical features suggestive of pathologic varus are listed in the table (table 2). (See 'Pathologic varus' above.)

● We suggest that radiographs be obtained in children with clinical features suggestive of pathologic varus (table 2). Radiographs should include both legs, from the hips to the feet, with the child standing and the patellas pointing straight ahead (image 5). (See 'Radiographs' above.)

● Children with clinical features suggestive of pathologic varus (table 2) should be referred to an orthopedic surgeon or other specialist as indicated (eg, endocrinologist, geneticist). (See 'Indications for referral' above.)

● The natural history of physiologic bow-legs is spontaneous resolution. We recommend that children with physiologic bow-legs (as defined in the text (see 'Physiologic varus' above)) be managed with observation and parental reassurance (Grade 1A). Orthotics (braces, splints, shoe inserts) are ineffective, unnecessary, and may have negative psychosocial sequelae. (See 'Physiologic bowing' above.)

● The management of pathologic bowing depends upon the underlying problem. Medical therapy for the primary disease should be optimized if effective medical therapy is available. Surgical therapy should be reserved for patients with residual therapy after medical optimization. (See 'Pathologic bowing' above.)

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REFERENCES


