Contemporary Management of Juvenile Blount Disease: The Evolving Role of Guided Growth

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Abstract

Background: Juvenile Blount disease is a progressive growth disturbance of the proximal tibial physis that produces pathologic genu varum and may be accompanied by internal tibial rotation, procurvatum, limb-length discrepancy, and progressive alteration of lower-limb mechanical alignment. The condition represents a complex interaction between abnormal mechanical loading and impaired medial physeal growth, with obesity, early walking, deformity severity, and remaining growth potential influencing its clinical course. Accurate assessment requires careful clinical examination combined with standing long-leg radiographs and systematic analysis of angular parameters, mechanical axis deviation, and disease stage. Management remains challenging because treatment must address both the existing deformity and the ongoing growth disturbance. Corrective osteotomy has traditionally provided reliable immediate realignment, particularly in advanced or severe deformities, but it is associated with greater surgical morbidity and potential complications. Guided growth has emerged as a less invasive alternative in skeletally immature patients by temporarily modulating growth across the lateral proximal tibial physis and allowing gradual correction through continued longitudinal growth. Tension-band plating is now widely used because of its technical simplicity, reversibility, and relatively favorable complication profile. However, treatment success is strongly dependent on patient selection, skeletal maturity, physeal viability, deformity magnitude, and timely intervention. Failure, incomplete correction, implant-related complications, rebound deformity, and eventual conversion to osteotomy may still occur. This review summarizes the contemporary evaluation and management of juvenile Blount disease, critically examines the evolving role of guided growth, and highlights the factors that determine its effectiveness relative to corrective osteotomy in modern pediatric orthopedic practice.

Keywords: Juvenile Blount disease, tibia vara, guided growth, tension-band plating

1. Introduction

Blount disease is a developmental disorder of the proximal tibial physis characterized by progressive varus deformity of the tibia and disturbance of normal lower-extremity alignment. Although the disorder is commonly divided into early- and late-onset forms, the term *juvenile Blount disease* traditionally describes presentation between approximately 4 and 10 years of age. This age group deserves particular attention because it lies between the classic infantile phenotype and the adolescent form: considerable growth may remain, yet the medial proximal tibial physis may already have sustained substantial pathologic change. The resulting deformity is therefore not simply a static genu varum but a dynamic growth disorder capable of progressive mechanical deterioration. [1]

The pathoanatomy is frequently multiplanar. Proximal tibial varus is the dominant deformity, but internal tibial torsion, procurvatum, medial physeal and epiphyseal depression, limb shortening, and secondary deformity elsewhere in the lower limb may coexist. In late-onset disease, distal femoral varus can also contribute meaningfully to overall mechanical-axis deviation. Persistent malalignment increases medial compartment loading and, when untreated, may produce progressive joint incongruity, abnormal gait, limb-length discrepancy, pain, instability, and premature degenerative change. Consequently, accurate localization of every component of deformity is essential before selecting treatment. [2]

The etiology remains incompletely defined and is probably multifactorial. Mechanical loading has a major role, particularly in association with childhood obesity, while biological susceptibility of the medial proximal tibial physis also appears important. The variable natural history and the occurrence of disease in children with different body habitus indicate that no single mechanical or genetic explanation is sufficient. Instead, a susceptible physis exposed to abnormal compressive and shear forces may progressively fail, creating a self-perpetuating cycle in which varus increases medial loading and medial growth suppression further worsens varus. [3]

Historically, corrective proximal tibial osteotomy represented the principal operative treatment for established juvenile tibia vara. Osteotomy offers immediate correction and can address multiplanar deformity, but it carries the morbidity of bone cutting, fixation, postoperative protection, neurovascular risk, compartment syndrome, infection, recurrence, and occasionally prolonged external fixation. The development of temporary hemiepiphysiodesis has therefore changed the treatment landscape by offering the possibility of correcting selected deformities through remaining growth rather than by immediate osteotomy. [4]

The major research gap is that the biological limits of guided growth in Blount disease remain incompletely defined. Published studies include heterogeneous combinations of infantile, juvenile, and adolescent patients, different deformity severities, different implants, variable definitions of success, and inconsistent follow-up to skeletal maturity. Consequently, the key clinical question is not whether guided growth *can* correct Blount deformity, but **which juvenile patients retain sufficient physeal potential for predictable correction and which should proceed directly to osteotomy or combined reconstruction**. This review therefore examines contemporary assessment and treatment of juvenile Blount disease, with particular emphasis on the rationale, indications, outcomes, limitations, and evolving role of temporary lateral tension-band plating. [5]

2. Pathogenesis and Development of the Deformity

Normal longitudinal growth of the proximal tibia depends on organized endochondral ossification across a healthy physis. In Blount disease, structural and functional abnormalities preferentially involve the posteromedial proximal tibial growth plate. Histopathologic studies have demonstrated disorganization of normal physeal architecture and disturbed endochondral ossification, findings consistent with abnormal mechanical stress acting upon a vulnerable physis. Continued asymmetric growth allows the lateral side to advance relative to the diseased medial side, producing progressive varus and altered proximal tibial geometry. [6]

Mechanical loading is particularly relevant because the proximal tibial physis is highly responsive to changes in compressive stress. Obesity increases the forces transmitted across the knee during weight bearing, and varus alignment moves the ground-reaction and mechanical axes medially, further increasing the bending moment across the proximal tibia. The result resembles a positive-feedback loop: medial overload suppresses growth, asymmetric growth increases varus, and increasing varus further magnifies medial loading. Epidemiologic and clinical literature consistently supports an association between increased body weight and Blount disease, although obesity should be regarded as a major modifying factor rather than a complete etiologic explanation. [3]

As the disorder progresses, the deformity becomes three-dimensional. Sabharwal and colleagues demonstrated that untreated Blount disease may include proximal tibial varus, procurvatum, and internal tibial torsion, with greater complexity in more severe disease. This observation has major therapeutic implications. Correction of a coronal radiographic angle alone does not necessarily normalize the limb if substantial sagittal or rotational deformity persists; therefore, patients considered for guided growth should be distinguished from those whose multiplanar deformity requires osteotomy. [7]

The entire limb should also be regarded as a functional unit rather than assuming all varus originates in the tibia. Gordon and colleagues demonstrated that distal femoral varus can contribute substantially to malalignment in late-onset tibia vara. In a juvenile child with marked mechanical-axis deviation, failure to measure the mechanical lateral distal femoral angle may therefore lead to inappropriate treatment of the tibia alone. Conversely, compensatory or apparent changes should not automatically prompt femoral surgery; treatment should be based on systematic deformity analysis rather than the visual appearance of the knee. [8]

Progressive disease may ultimately produce medial physeal tethering or a true bony bar, epiphyseal wedging, depression of the medial tibial plateau, and increasing joint-line obliquity. At that stage, simple lateral growth restraint cannot restore growth that has been permanently lost medially. This concept establishes the biological boundary of guided growth: temporary lateral hemiepiphysiodesis is most rational when the medial physis remains capable of growth, whereas advanced physeal arrest or major intra-articular deformity requires a different reconstructive strategy. [2]

3. Clinical and Radiographic Assessment

Clinical assessment begins with history, age at onset, progression of bowing, previous treatment, walking tolerance, pain, family history, nutritional or metabolic abnormalities, and change in body weight. Observation of standing alignment and gait should document bilateral versus unilateral involvement, lateral knee thrust, foot progression angle, and functional asymmetry. Examination should include limb lengths, rotational profile, knee range of motion, ligamentous stability, thigh-foot angle, hip rotation, and assessment for fixed flexion or sagittal deformity. Apparent genu varum should not automatically be attributed to Blount disease, particularly when metabolic bone disease, skeletal dysplasia, post-traumatic physeal disturbance, or physiologic alignment remain possibilities. [2]

The fundamental radiographic investigation is a properly positioned, standing, full-length anteroposterior radiograph of both lower extremities with the patellae facing forward whenever possible. The mechanical axis from the center of the femoral head to the center of the ankle should be assessed in relation to the knee, and the magnitude of mechanical-axis deviation recorded. Segmental analysis should include the mechanical medial proximal tibial angle (mMPTA) and mechanical lateral distal femoral angle (mLDFA), while the joint-line convergence angle can help identify a dynamic or intra-articular contribution to apparent coronal deformity. These measurements prevent the common error of assuming that every case of genu varum is an isolated proximal tibial deformity. [9]

The metaphyseal-diaphyseal angle described by Levine and Drennan remains historically important for differentiating early infantile tibia vara from physiologic bowing. An angle greater than approximately 11° was associated with subsequent development of radiographic tibia vara in the original series. Its greatest diagnostic value is therefore in younger children; in established juvenile disease, global mechanical-axis and segmental angular analysis are generally more informative for operative planning. Nevertheless, documenting metaphyseal morphology may still help characterize the underlying proximal tibial pathology. [10]

The Langenskiöld classification describes progressive radiographic changes involving the medial proximal tibial metaphysis, physis, and epiphysis from early irregularity and metaphyseal beaking to advanced physeal bridging. It remains widely cited in Blount literature and can communicate disease severity, but its limitations are important. The system was developed principally for early-onset disease, and studies have demonstrated only fair-to-moderate agreement among observers in some settings. It should therefore complement rather than replace quantitative deformity analysis, especially in juvenile patients in whom skeletal age, remaining growth, mechanical-axis deviation, and medial physeal viability may be more relevant to treatment selection. [11]

Advanced imaging is not required routinely, but magnetic resonance imaging can be useful when the radiograph suggests advanced medial physeal injury, physeal bar formation, substantial epiphyseal deformity, or when a guided-growth procedure is being considered despite concern regarding the biological capacity of the medial physis. MRI may demonstrate physeal morphology and cartilaginous anatomy not apparent on plain radiographs. Computed tomography has a more selective role, particularly for defining complex bony anatomy, rotational deformity, or a physeal bridge when such information will alter operative planning. [2]

The final radiographic analysis should answer four practical questions: where is the deformity located, in how many planes does it exist, how much correction is required, and does sufficient functional growth remain to achieve that correction? Guided growth is fundamentally dependent on time and growth potential; therefore chronological age alone is an inadequate indication. Bone age, pubertal status, physeal appearance, prior growth trajectory, magnitude of deformity, and rate of progression must be interpreted together. [1]

4. Treatment Principles and Decision-Making

The objective of treatment is not simply to create a cosmetically straight leg. Effective management should restore an acceptable mechanical axis, improve joint orientation, reduce pathologic medial loading, preserve knee motion, minimize limb-length inequality, and prevent progressive epiphyseal or articular deformation. The optimal procedure therefore varies according to remaining growth, severity, physeal viability, multiplanar components, obesity, and whether the deformity is primarily extra-articular or includes established tibial plateau depression. [2]

Observation has little role in clearly progressive juvenile Blount disease. Orthotic treatment has been most extensively studied in young children with early infantile disease, particularly Langenskiöld stage II, and results are poorer in bilateral or more advanced involvement. By the juvenile age range, bracing cannot reliably reverse a pathologic growth disturbance of the proximal tibia and should not delay appropriate operative intervention when serial radiographs demonstrate progression. [12]

A useful treatment distinction is between **growth-responsive deformity** and **growth-resistant deformity**. Growth-responsive disease occurs in a child with meaningful remaining growth, no established medial physeal bar, a deformity of a magnitude that can reasonably correct during the available growth period, and no advanced intra-articular depression requiring direct reconstruction. These patients may be candidates for temporary hemiepiphysiodesis. In contrast, severe multiplanar deformity, skeletal maturity or near maturity, major tibial plateau depression, complete or unresectable physeal arrest, or failed guided growth favors osteotomy, physeal-bar surgery in selected cases, or combined reconstruction. [13]

Obesity deserves specific consideration because it affects both disease biology and treatment mechanics. Increased body mass amplifies varus moments across the knee and may increase mechanical demands on tension-band constructs. Obesity should not automatically be treated as an absolute contraindication to guided growth, but it should lower the surgeon's threshold for careful implant selection, closer radiographic surveillance, counseling regarding slower or less predictable correction, and conversion to a more definitive procedure when the mechanical axis fails to improve. [3]

5. Corrective Osteotomy and Traditional Surgical Strategies

Proximal tibial osteotomy remains an essential component of contemporary Blount management. Its principal advantage is immediate correction independent of future growth. Depending on the technique, an osteotomy can correct varus, procurvatum, translation, and internal torsion simultaneously. This is particularly important when a juvenile patient presents with a deformity too severe to correct within the remaining growth period or with structural features that cannot be addressed by hemiepiphysiodesis alone. [14]

Acute correction may be performed using opening-, closing-, or dome-type osteotomies followed by internal or external fixation. Acute realignment has the advantage of a relatively short correction period but must respect neurovascular structures and the risk of compartment syndrome, especially when large angular or rotational corrections are attempted. The fibula may require management depending on osteotomy level and desired correction. Accurate identification of the center of rotation of angulation is critical to avoid unintended translation and secondary deformity. [14]

Gradual correction with circular or hexapod external fixation can be particularly useful in severe, multiplanar, recurrent, or complex deformity. It allows controlled adjustment after surgery and can simultaneously address translation, rotation, and length when required. The price is a longer treatment period, pin-site problems, frame intolerance, frequent follow-up, and a substantial burden for the child and family. Nevertheless, in advanced disease, gradual correction may be safer and more precise than forcing a large correction acutely. [15]

The continued importance of osteotomy is supported by systematic reviews showing marked heterogeneity in Blount surgical practice and insufficient evidence to define a single superior operation for all patients. Osteotomy techniques remain valuable because they do not depend on the medial physis recovering enough growth to remodel the deformity. Thus, the emergence of guided growth should not be interpreted as replacement of osteotomy; rather, it has shifted osteotomy toward patients in whom biology or deformity magnitude makes growth modulation unreliable. [15]

6. Guided Growth in Juvenile Blount Disease

6.1 Biological and Biomechanical Rationale

Temporary hemiepiphysiodesis corrects angular deformity by restraining growth on one side of an open physis while allowing relatively greater growth on the opposite side. In tibia vara, the implant is placed across the **lateral proximal tibial physis**. The intention is to slow lateral growth sufficiently for residual medial growth to reduce the varus relationship progressively. This mechanism is fundamentally different from an osteotomy: no immediate angular correction occurs at operation, and success depends entirely on subsequent physeal growth. [16]

This feature makes Blount disease biologically different from idiopathic genu valgum or genu varum. In idiopathic angular deformity the opposite side of the physis is usually normal; in Blount disease, the side that must “catch up” is itself pathologic. Accordingly, correction may be slower, incomplete, or absent if medial physeal damage is advanced. Comparative studies of temporary hemiepiphysiodesis have also shown that patients with pathologic physes experience higher complication or failure rates than children with otherwise normal physes. [17]

6.2 Evolution Toward Tension-Band Plating

Historical methods of growth modulation included physeal stapling and transphyseal screws. Tension-band plating was introduced as a reversible extraperiosteal alternative in which a small two-hole plate spans the physis and is fixed with an epiphyseal and a metaphyseal screw. As growth continues, the screws can diverge around the plate, producing a tethering effect rather than the rigid compression created by a fixed staple construct. Stevens' early clinical experience established the technique as an effective method for gradual correction of pediatric angular deformities. [16]

Comparative evidence does not support the assumption that an 8-plate invariably produces faster correction than staples. Wiemann and colleagues reported similar correction rates and overall complication rates between stapling and 8-plate hemiepiphysiodesis, while also demonstrating greater complications in patients with pathologic physes such as Blount disease. The major advantages of tension-band plating are therefore better understood as technical versatility, reversible extraperiosteal tethering, and avoidance of some staple-specific problems rather than guaranteed biological superiority. [17]

6.3 Surgical Principles

Accurate implant placement is essential. Under fluoroscopic guidance, the plate is centered over the lateral proximal tibial physis, with one screw placed in the epiphysis and one in the metaphysis without violating the joint or growth plate. The periosteum should be respected because unnecessary stripping may compromise the local biological environment. Screw length and trajectory should provide adequate purchase while permitting subsequent divergence. Implant placement that is excessively anterior or posterior can influence sagittal growth, whereas poor epiphyseal fixation may predispose to mechanical failure. [16]

Tension-band plating is attractive because weight bearing and knee motion can generally resume rapidly compared with osteotomy, there is no osteotomy union to await, and correction is gradual rather than acute. These advantages can be particularly valuable in children with bilateral disease or obesity, in whom postoperative immobilization after major reconstruction may be challenging. However, the apparently minor nature of the procedure should not encourage casual indications: the operation is simple only when the biology is favorable and the deformity has been analyzed correctly. [18]

6.4 Evidence in Blount Disease

Heflin, Ford, and Stevens reported guided growth of 27 limbs with pathologic tibia vara and found complete normalization of the mechanical axis in 78% of limbs. Their experience emphasized remaining growth and absence of an unresectable physeal bar as key prerequisites. The study helped expand the role of guided growth beyond conventional age-based algorithms and suggested that restoration of alignment can also improve associated ligamentous laxity and rotational appearance in selected patients. [19]

Maré and colleagues subsequently evaluated tension-band plates specifically in Blount disease. In 18 treated limbs, the varus deformity was effectively corrected in 78%, while normal mechanical alignment was achieved in 67% at a mean of approximately 18 months. Correction was faster in younger early-onset disease than in late-onset disease, illustrating the importance of growth velocity and age. Failure resulted not only from insufficient biological correction but also from delayed implant removal, screw fixation failure, and technical malposition. [20]

The evidence also warns against indiscriminate use in more advanced pathology. A systematic review by Fan and colleagues found that only about half of reported Blount segments treated with temporary hemiepiphysiodesis reached a neutral mechanical axis, while nearly half underwent an unplanned subsequent procedure. The data were heterogeneous and did not permit a simple age threshold or implant type to predict success. This reinforces that guided growth should be regarded as a treatment strategy requiring surveillance and possible staged intervention, rather than a guaranteed one-operation solution. [21]

More recent evidence suggests that guided growth can influence more than the coronal mechanical axis in appropriate early disease. Hanstein and colleagues evaluated tension-band plating in early-onset Blount disease and documented improvement in mechanical-axis parameters while examining changes in Langenskiöld stage after treatment. Although direct extrapolation to all juvenile disease should be cautious, such findings support the concept that unloading the diseased medial physis at an appropriate stage may favor radiographic remodeling as well as mechanical realignment. [22]

Particularly relevant to the present review, a 2026 study of juvenile and adolescent Blount disease reported successful correction into acceptable mechanical-axis zones in 61% of 44 extremities treated with guided-growth constructs. Higher body mass index was associated with failure, and mechanical implant failure remained a concern. These contemporary data support offering guided growth to selected older children, including some with substantial varus, while simultaneously demonstrating that failure remains sufficiently common to require realistic counseling and contingency planning. [23]

7. Outcomes, Predictors of Success, and Causes of Failure

Successful guided growth should be defined by restoration of acceptable global mechanical alignment rather than improvement in a single proximal tibial angle. Serial standing radiographs should assess mechanical-axis deviation, mMPTA, and—when abnormal—the mLDFA and joint-line orientation. Correction that improves mMPTA without bringing the mechanical axis toward a satisfactory knee zone may indicate an unrecognized femoral component, inadequate correction, joint-line pathology, or insufficient time. [8]

Remaining growth is probably the most fundamental predictor of success. A younger patient may have greater growth potential and therefore more capacity for correction, but younger age also means a longer period during which recurrent deformity may develop after implant removal. Conversely, an older juvenile patient may have a more predictable remaining course but insufficient time to correct a substantial deformity. Treatment should therefore be timed according to growth potential and severity rather than an isolated chronological-age cutoff. [21]

Disease severity and medial physeal integrity are equally important. Advanced Langenskiöld changes, substantial medial epiphyseal depression, established physeal bar formation, or severe mechanical-axis deviation suggest that the medial physis may lack enough functional capacity to respond to lateral tethering. In an infantile cohort, Griswold and colleagues found markedly more recurrence or persistence and reoperations in higher Langenskiöld stages, illustrating the biological principle that advanced physeal disease reduces the reliability of growth modulation. [24]

Obesity may adversely influence outcomes through several mechanisms: increased mechanical load on the diseased physis, greater forces on the plate-screw construct, and a larger corrective moment required to translate radiographic angular improvement into acceptable limb alignment. Contemporary juvenile/adolescent data showing higher BMI among treatment failures are therefore clinically plausible. Weight management should be addressed as part of comprehensive care, although surgery should not be postponed indefinitely while waiting for ideal weight reduction in a child with progressive deformity. [23]

The rate of correction varies substantially and should not be assumed from studies of idiopathic angular deformity. Slow correction may reflect reduced growth velocity, advanced medial physeal disease, improper implant position, or insufficient remaining growth. A child whose mechanical axis remains static on sequential studies deserves reassessment rather than automatic continuation of treatment until maturity. Repeated observation of a nonresponding construct can consume the limited growth that might otherwise have been used for alternative treatment. [20]

Recurrence after implant removal is another fundamental limitation. The plate modifies growth temporarily but does not remove the underlying biological susceptibility of the medial proximal tibial physis. If the pathologic growth imbalance persists after removal, recurrent varus may occur. Thus, normalization of alignment is not equivalent to cure. Children require follow-up after implant removal and preferably through skeletal maturity, particularly when substantial growth remains or when the original disease was severe. [25]

8. Complications and Technical Considerations

Complications of tension-band plating can be divided into biological, mechanical, technical, and timing-related problems. Biological failure manifests as absent or inadequate correction despite a functioning implant. Technical errors include inaccurate plate position, physeal violation, and misplaced epiphyseal screws. Mechanical problems include screw loosening or breakage and construct failure, particularly in heavily loaded proximal tibiae. Wound infection, although less common, can necessitate premature implant removal and jeopardize correction. [20]

Overcorrection is primarily a surveillance problem. Because correction continues while the lateral physis remains tethered, long intervals between radiographs may allow the mechanical axis to pass beyond the intended target. Once correction approaches neutral, follow-up intervals should be shortened according to age and correction velocity. Implant removal itself does not end management because subsequent rebound or renewed varus progression may develop. The surgeon must therefore balance the risk of overcorrection against the risk of recurrence after early removal. [19]

Screw breakage deserves specific attention in Blount disease. High mechanical loads, obesity, and prolonged treatment may increase stress at the plate-screw interface. Broken screws can complicate hardware removal and may signal that the construct has been exposed to substantial forces while correction remains incomplete. Scott's series of lateral tension-band plating identified infection and broken screws among causes of failure or delayed correction, underscoring the need for surveillance of hardware as well as alignment. [26]

A broader 2024 review of tension-band plating in infantile Blount disease found that the published evidence consists predominantly of retrospective studies and that reoperations remain common despite generally favorable correction rates. Although juvenile patients should not be equated directly with infantile patients, this evidence is important because it demonstrates the central limitation of the technique across Blount phenotypes: successful initial angular correction does not eliminate the possibility of repeated growth-modulation procedures, implant complications, recurrence, or eventual osteotomy. [27]

9. Guided Growth Versus Osteotomy: Where Does Each Fit?

The most useful contemporary question is not whether guided growth is superior to osteotomy, because the two procedures solve different problems. Guided growth is a **growth-dependent gradual correction strategy**. Osteotomy is a **growth-independent immediate deformity correction strategy**. When the medial physis remains functional and adequate growth time is available, guided growth can reduce surgical morbidity and potentially avoid an osteotomy. When growth is insufficient or the physis is irreversibly damaged, relying on guided growth is biologically unsound regardless of how attractive the minimally invasive operation appears. [21]

For a typical juvenile patient with an open proximal tibial physis, mild-to-moderate correctable varus, no major plateau depression, no established physeal bar, and sufficient remaining growth, lateral tension-band plating is a rational first surgical strategy. This is particularly compelling when coronal deformity dominates and rotational or sagittal components are limited. The patient and family should nevertheless understand that correction takes months rather than occurring immediately, repeated radiographs are mandatory, hardware removal is anticipated, and additional surgery may become necessary. [19]

In contrast, substantial multiplanar deformity, marked procurvatum or internal torsion, severe mechanical-axis displacement with little remaining growth, advanced epiphyseal depression, medial physeal bridging, or previous failed growth modulation should favor corrective osteotomy. Combined procedures may occasionally be appropriate when deformity exists at multiple levels or when one component is amenable to growth modulation while another requires acute correction. Such individualized planning is superior to applying an age-based algorithm alone. [7]

The available evidence does not justify presenting temporary hemiepiphysiodesis as universally safer or definitively superior. A 2023 systematic review and meta-analysis of 63 retrospective studies involving 1672 knees emphasized the generally low quality and heterogeneity of the surgical evidence. Recurrence differed among techniques and remained an important issue after hemiepiphysiodesis. The appropriate interpretation is therefore that guided growth has expanded the reconstructive spectrum and can reduce the need for osteotomy in carefully selected patients—not that it has replaced osteotomy as the definitive treatment for all juvenile Blount disease. [28]

10. Current Limitations and Future Directions

The principal limitation of the current literature is methodological. Most guided-growth publications are small retrospective case series combining different ages, Blount subtypes, deformity severities, and implant configurations. Definitions of successful correction vary from improvement in a single angle to normalization of mechanical-axis zones, while follow-up beyond implant removal is inconsistent. As a result, reported correction rates should not be interpreted as directly comparable between studies. [21]

Future investigations should stratify early-onset, juvenile, and adolescent disease rather than pooling them. Baseline reporting should include chronological and skeletal age, BMI, Langenskiöld or other physeal morphology, MAD, mMPTA, mLDFA, sagittal and rotational deformity, implant configuration, correction velocity, time to removal, recurrence, and outcome at or near skeletal maturity. Such standardized reporting would allow more meaningful identification of thresholds at which guided growth becomes unlikely to succeed. [27]

Another important research direction is prediction. Instead of deciding treatment largely from age and static radiographs, future models may combine skeletal maturity, serial growth velocity, BMI, mechanical-axis severity, MRI-defined physeal integrity, and correction rate after implantation. A validated prediction model could identify early nonresponders and allow conversion to osteotomy before valuable growth time is lost. The 2026 juvenile/adolescent data linking obesity and construct characteristics with outcome illustrate the type of clinically relevant information that larger multicenter studies should develop further. [23]

Ultimately, the major advance in juvenile Blount management is conceptual rather than implant-specific. Treatment is moving from a binary choice between observation and osteotomy toward staged, growth-conscious reconstruction in which the surgeon continually reassesses deformity biology. Guided growth is most effective when used early enough to exploit growth but selectively enough to avoid asking an irreversibly diseased physis to accomplish an impossible correction.

11. Conclusion

Juvenile Blount disease is a complex growth disorder that requires treatment according to deformity biology rather than chronological age alone. Accurate full-length radiographic analysis, assessment of multiplanar deformity, evaluation of remaining growth, and recognition of medial physeal damage are fundamental to selecting the appropriate procedure. Temporary lateral hemiepiphysiodesis with tension-band plating has established an important role in skeletally immature children because it can restore mechanical alignment gradually while avoiding the morbidity of corrective osteotomy in appropriately selected patients. Its minimally invasive character, however, should not obscure its dependence on residual medial physeal growth or the clinically important risks of incomplete correction, mechanical failure, overcorrection, recurrence, and reoperation. Corrective osteotomy therefore remains indispensable for severe deformity, advanced physeal disease, insufficient remaining growth, multiplanar abnormalities, and failed growth modulation. The contemporary strategy should not regard guided growth and osteotomy as competing procedures, but rather as complementary tools applied according to growth potential, deformity severity, and the biological capacity of the proximal tibial physis.

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