

The efficacy of guided growth as an initial strategy for Blount disease treatment

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Abstract

Purpose The aim of this study was to evaluate the success of guided growth by temporal hemiepiphyodesis of the lateral proximal tibia as a first line treatment option for Blount disease.

Methods This was a retrospective multicentre study conducted in five centres, covering data on 55 limbs in 45 patients, with an average follow-up of 24.5 months following plate insertion. Preoperative alignment analysis was compared with three measurements taken postoperatively. The normalization of the mechanical medial proximal tibia angle (mMPTA) was defined as the primary outcome measure.

Results Mean age at surgery was 9.5 years. Average preoperative mMPTA was 77°. On average, at 24.5 months post-surgery, mMPTA was 86.33°, while 43/55 limbs (78.18%) have achieved normalization (mMPTA 85° to 90°). Average rate of correction was 1° per month. When grouping the children as infantile (11 limbs), juvenile (12 limbs) and adolescent (32 limbs), operated on before the age of four years, between four and ten years and after the age of ten years,

respectively, 63.63%, 66.67%, 87.5% have completed correction of deformity during the follow-up period. Interestingly, the femoral component of the deformity has achieved correction as well in 33/55 limbs (64%).

Conclusion Hemiepiphyodesis is an effective first line treatment for Blount disease. Overall success rate is good but varies according to child's age. Adolescent Blount has the best chance of achieving full correction while same treatment is less effective in infantile Blount.

Level of evidence: IV

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Introduction

Blount disease (tibia vara) is commonly attributed to a defect in the proximal tibial physis, resulting in a progressive knee varus, procurvatum and internal rotation deformity of the tibia. It was first described by Blount in 1937.¹ Blount disease can be classified as infantile, or early onset form, which appears before the age of four years, juvenile, which appears between four and ten years and adolescent, or late onset form, which appears in children older than ten years.²⁻⁴ Incidence of infantile Blount disease is rising in the United States in concordance with the increasing rate of obesity in children.⁵

Surgical treatment options include tibial osteotomies with either acute⁶ or gradual correction⁷ and proximal lateral tibial hemiepiphyodesis (guided growth) the latter being less invasive and with significantly lower rate of major complications.⁸

Guided growth by tension band plating (TBP) is commonly used to correct coronal plane deformity around the knee. Since its introduction by Stevens in 2007⁹ many studies have demonstrated the efficacy, safety and advantages of TBP in the paediatric age group as an alternative to corrective osteotomy.¹⁰

The aim of this study was to evaluate the efficacy, rate of correction and complications of guided growth by temporal hemiepiphyodesis with TBP of the lateral proximal

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tibia as a first line treatment option for Blount disease (tibia vara) in various age groups.

Materials and methods

The retrospective multicentre study was based on treatment conducted in five centres. In each centre authorization was obtained from the local institutional review board. Inclusion criteria were skeletally immature patients over 1.5 years of age who presented with tibia vara; all patients were treated by various types of TBP as the primary line of treatment and had provided at least one pre-operative and three postoperative digital based full-length anteroposterior weight-bearing radiographs.

Immediate mobilization and full weight-bearing was encouraged after surgery. No casting or bracing were used postoperatively. Patients were subsequently evaluated in a clinical setting, typically at three to six months intervals, for clinical evaluation and full-length anteroposterior weight-bearing radiographs.

Exclusion criteria consisted in failed prior treatment, including tibial osteotomy.

We have collected and analyzed data on 55 treated limbs in 45 patients (28 male, 17 female) with a mean follow-up of 24.5 months (12 to 53) after plate insertion.

Deformity analysis of all radiographs was performed in each centre by a designated investigator using the

TraumaCad software (Voyant Health, a Brainlab company, Munich, Germany).

This method has been shown by Segev et al¹¹ to be a reliable tool in terms of intra- and interobserver variability.

The mechanical medial proximal tibial angle (mMPTA) was recorded and analyzed. In all patients, the goal of treatment was to restore normal value considered as 87° (SD 2°).¹² Mean rate of correction (ROC) in °/month was calculated. The mechanical lateral distal femoral angle (mLDFA) was recorded and analyzed as well.

Study data were analyzed for the entire group and for subgroups according to age at operation: The infantile group included patients operated on before the age of four years (eight patients, 11 limbs); the juvenile group patients operated on at ages four to ten years (nine patients, 12 limbs); and the adolescent group patients operated on after the age of ten years (28 patients, 32 limbs).

Data were also compared with the results of our previous study on growth modulation in idiopathic angular knee deformities.¹³ We compared the idiopathic varus group (26 children, 43 limbs, Mean age 13.25 years, range 7.9 to 16.7; SD 2.3) who were treated with lateral proximal tibial hemiepiphyseodesis to the current adolescent subgroup.

All medical records for each patient were reviewed, including surgical reports and radiographs. Information collected included sex, age at surgical intervention and

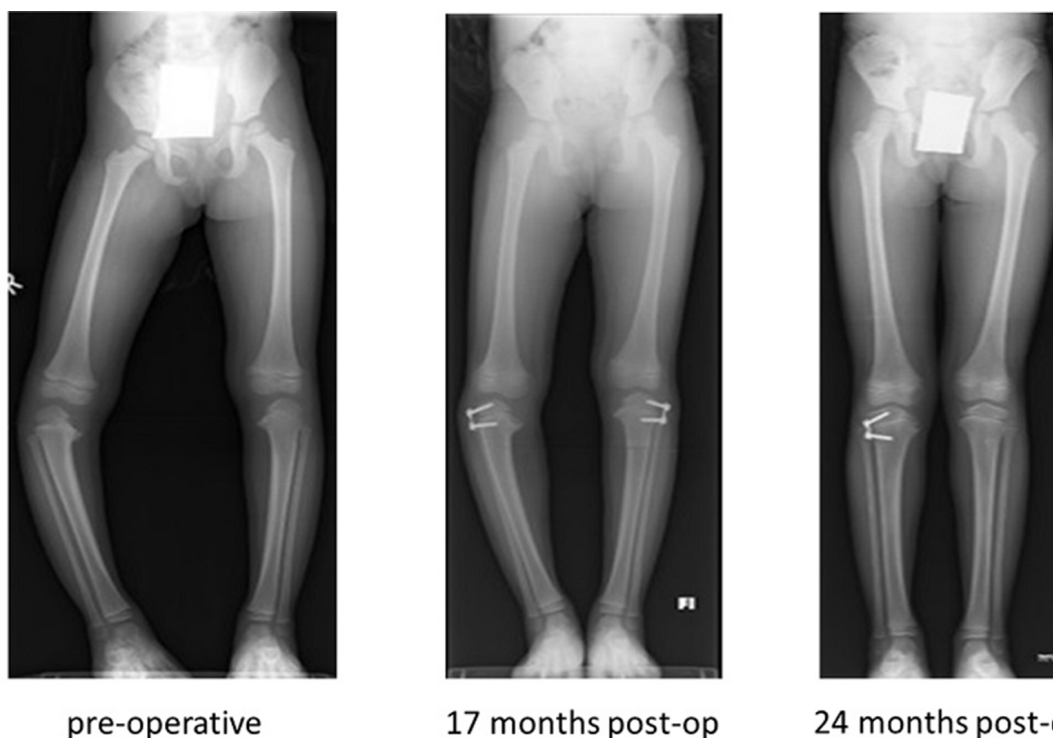


Fig. 1 Three years and 11 months old girl with infantile Blount who was operated with lateral proximal tibial hemiepiphyseodesis. Gradual deformity correction is demonstrated.

Table 1 Mechanical medial proximal tibial angle (mMPTA) values and rate of normalization during mean follow-up

		Preoperative	First postoperative (6.92 mths)	Second postoperative (15.25 mths)	Third postoperative (24.5 mths)
Total (45 children, 55 limbs)	mMPTA (range; SD)	77 (61 to 85; 5.7)	81.2 (66 to 93; 6.4)	84.2 (67 to 98; 7.6)	86.3 (66 to 97; 6.7)
	Normalization, %	-	32.7	74.5	78.2
Infantile (8 children, 11 limbs)	mMPTA (range; SD)	77.9 (63 to 84; 5.6)	82.9 (66 to 93; 6.2)	90.6 (83 to 98; 4.9)	90.7 (87 to 97; 3.2)
	Normalization, %	-	27.2	45.5	63.6
Juvenile (9 children, 12 limbs)	mMPTA (range; SD)	76.2 (67 to 82; 4.1)	77.7 (69 to 87; 7)	78.3 (70 to 87; 7.2)	82 (71 to 90; 7.5)
	Normalization, %	-	33.3	58.3	66.7
Adolescent (28 children, 32 limbs)	mMPTA (range; SD)	77.2 (61 to 85; 6.1)	81.8 (70 to 91; 5.6)	83.8 (67 to 90; 6.8)	86.6 (66 to 95; 6.3)
	Normalization, %	-	34.4	71.9	87.5
Idiopathic*(14) (26 children, 43 limbs)	mMPTA (range; SD)	81.8 (71 to 85; 4.8)	85.2 (76 to 98; 4.1)	85.6 (79 to 90; 2.8)	87.5 (80 to 106; 4.1)
	Normalization, %	-	67.4	81.4	93

*idiopathic varus group from our previous study who was treated with lateral proximal tibial hemiepiphyodesis

perioperative complications. Data were collected by each centre using a web-based database.

Statistical analysis

Paired *t*-test was used to determine statistically significant differences among Blount subgroups as well as between idiopathic genu varum and adolescent Blount subgroup.

Results

In total, 45 patients (28 male, 17 female) with 55 affected tibiae underwent guided growth hemiepiphyodesis with TBP (Fig. 1). Two patients also had distal femur hemiepiphyodesis.

Mean age at surgery for the entire group was 9.5 years (1.58 to 14.83). Preoperative and postoperative mMPTA measurements and rate of patients' achieved correction are listed in Table 1. No difference was found in age, sex and preoperative mMPTA in limb correction failure as compared with limbs that have completed normalization.

The average ROC was 1° per month during all follow-up periods.

When subgrouping the patients into infantile, juvenile and adolescent, the ROC is different for each group as well as for each follow-up period (Table 1).

Normalization rate of the idiopathic genu varum group (93%) was higher than in the Blount group (78.18%).

Differences in ROC (° per month; °/m) between adolescent Blount in comparison with idiopathic genu varum were found as well as among the Blount subgroups. Due to the small number of patients they appear to be statistically insignificant (Table 2). ROC of idiopathic varus group in comparison with adolescent Blount group in the first year was 0.77°/m compared with 1°/m, respectively (p = 0.68). In the second year correction rate was 0.79°/m compared with 1.35°/m respectively (p = 0.49).

Table 2 Rate of correction

	Rate of correction first year (°/month)	Rate of correction second year (°/month)
Total study group	1	1
Infantile subgroup	0.45	0.8
Juvenile subgroup	1.5	0.5
Adolescent subgroup	1	1.3
Idiopathic group*(14)	0.77	0.79

*idiopathic varus group from our previous study treated with lateral proximal tibial hemiepiphyodesis

It appears that adolescent Blount corrects faster than infantile Blount but with no statistical significance; in the first year 1°/m compared with 0.45°/m, respectively (p = 0.08) and in the second year 1.35°/m compared with 0.8°/m, respectively (p = 0.77).

It also appears that adolescent Blount corrects slower than juvenile Blount in the first year but again with no statistical significance; 1°/m compared with 1.5°/m, respectively (p = 0.93). In the second year it appears to correct faster (statistically insignificant); 1.35°/m compared with 0.52°/m, respectively (p = 0.48).

Juvenile Blount corrects faster than infantile Blount in the first year; 1.5°/m compared with 0.45°/m, respectively (p = 0.06) and slower in the second year; 0.52°/m compared with 0.8°/m, respectively (p = 0.06).

Interestingly, the femoral component of the deformity was partially corrected as well (Table 3) although only two patients (two limbs) had distal femur hemiepiphyodesis: in 28 patients (45 limbs) the initial mL DFA was either above 90° or below 85°. At the first postoperative follow-up (mean 6.9 months range 1.4 to 36.1; SD 7.8 post-operatively) mean mL DFA was 91.3° (74° to 107°; SD 5.9°) while 20/55 limbs (36%) completed normalization. At the second postoperative follow-up (mean 15.25 months, range 4.8 to 38.8; SD 7.5 on average postoperatively) mean mL DFA was 89.4° (75° to 106°; SD 5.9°), while 27/55 limbs (49%) completed normalization. At the third postoperative

Table 3 Mechanical lateral distal femoral angle (mLDFA) values and rate of normalization during mean follow-up

		Preoperative	First postoperative (6.92 mths)	Second postoperative (15.25 mths)	Third postoperative (24.5 mths)
Total (28 children, 45 limbs)	mLDFA (range; sd)	97 (74 to 120; 8.3)	91.3 (74 to 107; 5.9)	89.4 (75 to 106; 5.9)	88.9 (80 to 102; 4.5)
	Normalization, %	-	36	49	64

follow-up (mean 24.5 months range 3.9 to 42.2; sd 7.6 postoperatively), mean mLDFA was 88.9° (80° to 102°; sd 4.5°), while 35/55 limbs (64%) completed normalization.

The contribution of the tibial deformity as a percentage of the total deformity (%DT) (the deviation from 87°, the normal value of mMPTA divided by the sum of deviation from the normal value of mLDFA and mMPTA) was calculated, separately for the limbs that achieved normalization (55.18%) and those limbs that didn't (63.12%). The difference was not statistically significant (p = 0.19).

Complications included three limbs with growth plate closure (5.45%), two of screw failure (3.6%). Both of them were '8 plate' and in both children one cannulated screw was broken. There was also one child (1.8%) with early (within one-month postoperative) restricted range of movement which resolved with physiotherapy.

Discussion

This study presents one of the largest published data on temporary hemiepiphyodesis as a first line of treatment in Blount disease.

Burghardt et al¹⁴ published a review on 63 knees in 47 patients with Blount disease treated with temporary hemiepiphyodesis where they used staples in some of the patients for permanent hemiepiphyodesis rather than temporal as in our current study. Other studies found in the literature are listed in Table 4. Another uniqueness of this study is the data regarding ROC as well as efficacy of temporary hemiepiphyodesis as a primary treatment

in Blount according to different age subgroups; our study presents data regarding the full spectrum of ages in Blount disease.

A total of 43 out of 55 limbs (78.2%) in our study completed normalization (mMPTA between 85° and 90°). These rates correlate with Heflin et al's¹⁵ report on 17 patients with 27 limbs who were managed by means of guided growth of the proximal tibia. In their study 78% of the limbs had complete normalization of their mechanical axis (middle 50% of knee). Comparing the data from the literature regarding normalization rate is difficult because specific age is usually not indicated while parameters of treatment normalization are varied.

Normalization rate in the entire Blount study population as found in our current study (78%) is lower than in the idiopathic corresponding age group in which 40/43 limbs (93%) completed normalization.¹³

Normalization rate was lower in the younger subgroups: at the third postoperative follow-up (24.5 months on average postoperatively), only 63.63% and 66.67% of the infantile and juvenile groups respectively completed normalization (mMPTA between 85° and 90°). This finding may be a result of the second growth-spurt of adolescence but does not correlate with data from Bushnell et al¹⁶ who found a significant correlation between increasing age at surgery and decreasing amounts of tibial correction (they have used staples and ablation for hemiepiphyodesis).

When comparing the age, sex and initial deformity of the patients which have not completed normalization no significant difference was found in either parameter.

Table 4 Data in the literature compared with our current study data

	Method	Number of patients (limbs)	Results	Mean age (yrs) at surgery
Current study	Tension band plate (various)	45 (55)	78% normal mMPTA (85° to 90°)	9.5 (adolescent-best)
Shabtai and Herzenberg ¹⁷	Tension band plate	33 (38)		No data – review article
Heflin et al ¹⁵	Tension band plate	17 (27)	78% mechanical axis at middle 50% of knee	Better results in the infantile subgroup
Murphy et al ²³	Transphyseal screws	9 (knees)	MAD from 46 mm to 0 mm, mMPTA from 81° to 92°	All patients were 12 yrs or younger. No age subgrouping
Bushnell et al ¹⁶	Staples + ablation	47 (63 knees)	Average correction was 9°, ranging from 33° of correction to 6° of worsening	Significant correlation between increasing age and decreasing amounts of tibial correction
Park et al ²⁴	Staples	26 (33 knees)	MAD from 58 mm to 22 mm, mMPTA from 77° to 85°	Best results in patients under 10 yrs old
Funk et al ²⁵	Staples, pediplates, eight-plate	25 (38 knees)	Failure rate: 57.9% (need for osteotomy or MAD > 40 mm)	11.5 (not a risk factor)
Schroerlucke et al ¹⁹	Eight-plate	23 (31 knees)	Failure rate: 44%	11 (not a risk factor)
Scott ²⁶	Tension band plate (diverse)	12 (18)	Failure rate: 11%	4.8
Jain et al ²⁰	Eight-plate; pediplates	40 (61 knees)	Failure rate: 40%	9.6 (not a risk factor)

mMPTA, mechanical medial proximal tibial angle; MAD, mechanical axis deviation.

Due to the relatively small number of patients in each subgroup we were unable to classify them according to the severity of the deformity; further studies with larger number of patients are needed in order to better define the indication in the younger age group.

The difference between the two groups (Blount and idiopathic) might be explained by the different habitus of Blount patients⁴ who are more likely to have surgical or implant failure,¹⁷ as well as a different pathology mechanism in the growth plate in Blount.

ROC for the entire study group was 1°/m on average during the follow-up period. In our previous study of growth modulation in idiopathic angular knee deformities¹³ we found that the ROC of varus deformity in the tibia was 0.82°/m. The average age of those idiopathic 26 patients (43 limbs) was 13.25 years and the average follow-up was 16 months. When the idiopathic group is compared with the adolescent Blount subgroup, i.e. 28 patients (32 limbs) of our current study, it seems that the ROC is higher in the adolescent Blount, 1°/m and 1.35°/m during the first and second year after plate insertion, respectively. However, the difference is not statistically significant.

We also found differences in the ROC as well as efficacy between the age subgroups; infantile, juvenile and adolescent Blount. During the first year of correction the infantile subgroup has the slowest rate while juvenile is the fastest, but these differences are not statistically significant.

It is worth noting that the femoral component of the deformity was partially corrected as well, although only two patients (two limbs) had distal femur hemiepiphysiodesis: this is the first evidence for concurrent 'spontaneous' correction of the femoral deformity without any manipulation on the femur – with a reasonable normalization rate of about 2/3 of the deformed femurs in 24 months' follow-up.

Bowen et al¹⁸ found that the contribution of the tibial deformity (%DT) can be used as a predictor to progression in patients with infantile genu varum. We calculated a slightly different %DT and found that the difference between limbs that achieved normalization and limbs that have not was not statistically significant.

The main complication described in the literature is screw breakage. In their review, Shabtai and Herzenberg¹⁷ describe 9/38 (23.7%) patients with broken screws in Blount disease treated with TBP.

According to their review, broken TBP screws are mostly limited to overweight Blount disease patients. This complication may be mitigated, but not eliminated, by using solid (not cannulated) screws and double TBPs. Schroerlucke et al¹⁹ and Jain et al²⁰ found mechanical failure rates of 26% and 11%, respectively. All failure cases in both studies involved cannulated metaphyseal screws.

We had a rate of 2/55 (3.6%) screw breakage. Patients in our study were treated by various types of TBP, including cannulated and solid screws, which might explain the difference in complication rate.

There are several limitations in our study that should be acknowledged: we were unable to estimate the impact of weight on failure due to limited data on this parameter. Data collected did not include measurement of mechanical axis deviation which primarily affects the knee but also has an effect on the hip, ankle and subtalar joints.²¹ This study is focused on tibia vara, which is better represented by mMPTA. We were unable to assess rebound growth due to insufficient follow-up data gathered until skeletal maturity in some of the patients. The rebound phenomenon requires further study, but since it is a simple and well tolerated procedure, it does not preclude re-treatment if it occurs.⁹ It is also possible that a longer follow-up would demonstrate a higher normalization rate. Due to the retrospective-multicentre design of the study, there is a challenge in using radiographic classification²² as probable predictors for success of guided growth.

We have divided the age groups into infantile (below four years), juvenile (four to ten years) and adolescent (ten years and above) according to age at the onset of the disease, which is the common terminology in the literature.² Other studies have used different terminologies such as early onset (below four years) and late onset (four years and above) which may give a reason to the diversity in the results.

In conclusion, hemiepiphysiodesis in Blount disease is an effective first line treatment. Overall efficacy is good but varies according to child's age, with adolescent Blount having the best chance of achieving full correction while the infantile/juvenile groups experience less favourable results.

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COMPLIANCE WITH ETHICAL STANDARDS

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OA LICENCE TEXT

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ETHICAL STATEMENT

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later

amendments or comparable ethical standards. This is a retrospective multicentre study - conducted in five centres. In each centre, authorization was obtained from the local institutional review board.

Informed consent: Due to its retrospective characteristics, informed consent was waived.

ICMJE CONFLICT OF INTEREST STATEMENT

RR reports receipt of personal fees from Nuvasive, royalties from Merete Medical, Nuvasive, Smith & Nephew, Kyowa Kirin and Biomarine; royalties from Merete Medical, outside the submitted work.

SW is Editor in Chief of the *Journal of Children's Orthopaedics*.

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The other authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

BD: Study design, Measurements, Statistical analysis, Manuscript preparation.

RR: Measurements.

JEH: Measurements.

LS: Measurements.

FG: Measurements.

UN: Measurements.

RG: Measurements.

ES: Study design.

SW: Study design, Manuscript preparation.

REFERENCES

- Blount WP.** Tibia Vara. Osteochondrosis deformans tibiae. *J Bone Joint Surg [Am]* 1937;19-A:1-29.
- Birch JG.** Blount disease. *J Am Acad Orthop Surg* 2013;21:408-418.
- Sabharwal S.** Blount disease. *J Bone Joint Surg [Am]* 2009;91-A:1758-1776.
- Bradway JK, Klassen RA, Peterson HA.** Blount disease: a review of the English literature. *J Pediatr Orthop* 1987;7:472-480.
- Güven A, Hancılı S, Kuru LI.** Obesity and increasing rate of infantile Blount disease. *Clin Pediatr (Phila)* 2014;53:539-543.
- Martin SD, Moran MC, Martin TL, Burke SW.** Proximal tibial osteotomy with compression plate fixation for tibia vara. *J Pediatr Orthop* 1994;14:619-622.
- Mayer SW, Hubbard EW, Sun D, Lark RK, Fitch RD.** Gradual deformity correction in Blount disease. *J Pediatr Orthop* 2019;39:257-262.
- Payman KR, Patenall V, Borden P, Green T, Otsuka NY.** Complications of tibial osteotomies in children with comorbidities. *J Pediatr Orthop* 2002;22:642-644.
- Stevens PM.** Guided growth for angular correction: a preliminary series using a tension band plate. *J Pediatr Orthop* 2007;27:253-259.
- Danino B, Rödl R, Herzenberg JE, et al.** Guided growth: preliminary results of a multinational study of 967 physes in 537 patients. *J Child Orthop* 2018;12:91-96.
- Segev E, Hemo Y, Wientroub S, et al.** Intra- and interobserver reliability analysis of digital radiographic measurements for pediatric orthopedic parameters using a novel PACS integrated computer software program. *J Child Orthop* 2010;4:331-341.
- Paley D.** *Principles of deformity correction.* Herzenberg JE, ed. Berlin, Heidelberg: Springer-Verlag, 2002.
- Danino B, Rödl R, Herzenberg JE, et al.** Growth modulation in idiopathic angular knee deformities: is it predictable? *J Child Orthop* 2019;13:318-323.
- Burghardt RD, Herzenberg JE, Strahl A, Bernius P, Kazim MA.** Treatment failures and complications in patients with Blount disease treated with temporary hemiepiphyseodesis: a critical systematic literature review. *J Pediatr Orthop B* 2018;27:522-529.
- Heflin JA, Ford S, Stevens P.** Guided growth for tibia vara (Blount's disease). *Medicine (Baltimore)* 2016;95:e4951.
- Bushnell BD, May R, Campion ER, Schmale GA, Henderson RC.** Hemiepiphyseodesis for late-onset tibia vara. *J Pediatr Orthop* 2009;29:285-289.
- Shabtai L, Herzenberg JE.** Limits of growth modulation using tension band plates in the lower extremities. *J Am Acad Orthop Surg* 2016;24:691-701.
- Bowen RE, Dorey FJ, Moseley CF.** Relative tibial and femoral varus as a predictor of progression of varus deformities of the lower limbs in young children. *J Pediatr Orthop* 2002;22:105-111.
- Schroerlucke S, Bertrand S, Clapp J, Bundy J, Gregg FO.** Failure of Orthofix eight-Plate for the treatment of Blount disease. *J Pediatr Orthop* 2009;29:57-60.
- Jain MJ, Inneh IA, Zhu H, Phillips WA.** Tension band plate (TBP)-guided hemiepiphyseodesis in Blount disease: 10-year single-center experience with a systematic review of literature. *J Pediatr Orthop* 2020;40:e138-e143.
- Paley D, Tetsworth K.** Mechanical axis deviation of the lower limbs. Preoperative planning of uniapical angular deformities of the tibia or femur. *Clin Orthop Relat Res* 1992;280:48-64.
- LaMont LE, McIntosh AL, Jo CH, Birch JG, Johnston CE.** Recurrence after surgical intervention for infantile tibia vara: assessment of a new modified classification. *J Pediatr Orthop* 2019;39:65-70.
- Murphy RF, Pacult MA, Barfield WR, Mooney JF III.** Hemiepiphyseodesis for juvenile and adolescent tibia vara utilizing percutaneous transphyseal screws. *J Pediatr Orthop* 2020;40:17-22.
- Park SS, Gordon JE, Luhmann SJ, Dobbs MB, Schoenecker PL.** Outcome of hemiepiphyseal stapling for late-onset tibia vara. *J Bone Joint Surg [Am]* 2005;87-A:2259-2266.
- Funk SS, Mignemi ME, Schoenecker JG, et al.** Hemiepiphyseodesis implants for late-onset tibia vara: a comparison of cost, surgical success, and implant failure. *J Pediatr Orthop* 2016;36:29-35.
- Scott AC.** Treatment of infantile Blount disease with lateral tension band plating. *J Pediatr Orthop* 2012;32:29-34.