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Infantile Tibia Vara*

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Infantile tibia vara is a developmental disorder of growth that affects the medial aspect of the proximal tibial physis. Blount's article in 1937 prompted recognition of this disorder, and, in fact, infantile tibia vara is often called “Blount’s disease.” Blount also described an adolescent form of tibia vara. It is now generally accepted that although the two forms have some similar anatomical and epidemiological features, the disorder of adolescent tibia vara should be considered different from that of infantile tibia vara.

Children with infantile tibia vara have no apparent abnormality at birth, they are generally healthy, and early growth of the legs is within normal limits. These children are usually brought to a physician at fourteen to thirty-six months old for evaluation of bow legs. A typical history is that the genu varum had gotten worse since walking began. Infantile tibia vara is found more frequently in children who are black, female, and obese and who started walking at an early age (Fig. 1)12,22,27,29,36,38.

Nine to 43 per cent of patients have been reported to have an affected parent or sibling2,34, but the spectrum of infantile tibia vara within a family is usually consistent with a multifactorial rather than a mendelian pattern of inheritance. The disorder is localized to the proximal part of the tibia, and any genetic or familial influence is probably related to factors such as obesity or age at the initiation of walking rather than to an enzymatic defect of bone growth.

The etiology of infantile tibia vara is best explained as abnormal compression on the medial aspect of the proximal tibial physis, causing retardation of growth from that area or increased growth from the proximal aspect of the fibula and the lateral aspect of the proximal part of the tibia, or both35. The association of early walking, black race, female gender, and obesity in these children supports that explanation. If a child begins walking at an early age, when the knees are still aligned in marked varus, then weight-bearing compressive forces will be greater on the medial aspect of the physis. Black and female children walk at an earlier age than white and male children do4, and this factor may account for the greater preponderance of black children and girls with infantile tibia vara. Obesity also increases compression at the physis. These clinical observations were supported by a study that used finite element analysis. In this study, Cook et al.5 calculated that 20 degrees of genu varum in a two-year-old child of normal weight retards growth from the medial aspect of the proximal tibial physis. Obesity and increased height, as seen in an older child, decreased the degree of genu varum necessary to cause abnormal compression on the medial side of the proximal tibial physis.

Histological changes observed in the medial portion of the tibial physis are consistent with increased compression and reduced growth in these areas. These histological changes include (1) islands of densely packed cartilage cells showing more hypertrophy than normal, (2) islands of almost acellular fibrous cartilage, and (3) abnormal groups of capillary vessels14,25.

Continued compression results in limited growth of both the physis and the epiphysis. The medial aspect of the epiphysis becomes narrowed, and longitudinal growth from the medial aspect of the metaphysis is inhibited. Persistent internal tibial torsion also occurs, the etiology of which is uncertain, but I speculate that it may be related to a relative overgrowth of the fibula that blocks normal development of external tibial torsion34. Eventually, changes in the growth plate become irreversible and premature bridging of the medial aspect of the proximal tibial physis occurs. When patients are not treated, severe degenerative joint disease develops during early adulthood35.

Differential Diagnosis and Examination

For the orthopaedic surgeon, genu varum as a diagnostic question is most common in the fourteen to thirty-six-month-old child. Bowleg deformity that causes concern before that time occurs in children who have either extremely short stature and an obvious skeletal dysplasia or some other systemic problem that has previously been evaluated and diagnosed.

Evaluation of the fourteen to thirty-six-month-old child with genu varum should include screening of developmental milestones and plotting of the child's
height and weight on standard growth charts. Physical examination includes a brief survey of the entire lower extremity. The degrees of genu varum and tibial torsion are specifically measured and recorded. Knee motion and ligamentous instability are also assessed. In the older child with untreated infantile tibia vara, mild laxity of the lateral collateral ligament is common, but a fourteen to thirty-six-month-old child with this condition usually has ligamentous stability that is within normal limits.

The next decision in the process of evaluation is whether radiographs of the knees are warranted. I obtain radiographs for the following reasons: (1) genu varum that is relatively severe for the child’s age; (2) genu varum that, according to the patient’s history, has not improved or has gotten worse over the previous three to four months; (3) excessive internal tibial torsion; (4) a height less than the twenty-fifth percentile; (5) a positive family history for genu varum; or (6) marked asymmetry of limb alignment. These factors make it more likely for the child to have some condition other than physiological genu varum.

Two studies have charted the normal development of the femoral-tibial angle and are helpful in the determination of whether a child’s genu varum is a matter for concern. Salenius and Vankka used radiographs to measure the femoral-tibial angle in a relatively homogeneous Finnish population. Engel and Staheli derived measurements from clinical photographs of a more heterogeneous population of children in Seattle, Washington. Both studies demonstrated that normal knee alignment progresses from 10 to 15 degrees of varus at birth to a maximum or peak valgus angulation of 10 to 15 degrees at the age of three to three and one-half years. The studies differed in terms of the age at which neutral femoral-tibial alignment was reached. Engel and Staheli observed neutral femoral-tibial alignment when their patients were an average of twelve to fourteen months old, but Salenius and Vankka noted neutral alignment when their patients were an average of twenty to twenty-two months old. On the basis of clinical measurement of genu varum with a goniometer, I have observed that neutral femoral-tibial alignment usually develops by fourteen months old.

For the fourteen-month to three-year-old child with no history of previous trauma or infection, the differential diagnosis of genu varum includes physiological bow legs, infantile tibia vara, hypophosphatemic rickets, metaphyseal chondrodysplasia, and focal fibrocartilaginous dysplasia. Physiological bow legs is the most common cause of genu varum in this age group. These children have genu varum that persists after eighteen months old but their bowleg alignment will spontaneously resolve, usually before the age of three. The primary consideration in these children is to rule out other disorders and to reassure the parents.

Typical radiographic characteristics of physiological bow legs include symmetrical involvement, a normal-appearing growth plate, and medial bowing of both the proximal part of the tibia and the distal part of the femur. The radiographic appearance and the femoral-tibial angle may be similar in physiological bow legs and infantile tibia vara, particularly in a child who is less than two years old. The metaphyseal-diaphyseal angle, however, can be helpful in the differentiation of these two conditions (Figs. 2 and 3). In the study of Levine and Drennan, physiological bow legs was the ultimate diagnosis in forty-nine of fifty-two children who had a metaphyseal-diaphyseal angle of 11 degrees or less; however, infantile tibia vara developed in all children with a metaphyseal-diaphyseal angle of 12 degrees or more.

Subsequent studies have shown that measurement of the metaphyseal-diaphyseal angle is reproducible between observers. The mean intraobserver difference, however, is 2.0 ± 2.0 degrees, and some orthopaedic surgeons advocate that the metaphyseal-diaphyseal angle should be at least 14 to 16 degrees before a diagnosis of infantile tibia vara is presumed and treatment is prescribed.

Hypophosphatemic rickets is the most common type of rickets in the United States. Its unique sex-linked dominant inheritance pattern may lead to early recog-

...nition, but in many cases the diagnosis is made after the child starts walking. Short stature and genu varum are clinical features that stimulate parental concern and a visit to a physician. The height at the initial diagnosis is usually less than the tenth percentile and always less than the twenty-fifth percentile. Abnormal genu varum is observed in 95 per cent of patients who have hypophosphatemic rickets.

Metaphyseal chondrodysplasia is an inherited disorder of bone growth that also causes bowing of the lower extremities. In the most common type of metaphyseal chondrodysplasia (Schmidt pattern), height and limb alignment are within normal limits at birth, but genu varum persists and retarded growth becomes obvious in the preschool years.

Hypophosphatemic rickets and metaphyseal chondrodysplasia are often misdiagnosed. The key to the identification of these disorders is the radiographic appearance of the physis. Both are characterized by widening or rachitic-like changes at the physis (Fig. 4). These changes, however, are not as extreme as those seen in nutritional or vitamin D-deficient rickets. Low serum phosphorus levels distinguish hypophosphatemic rickets from metaphyseal chondrodysplasia.

Focal fibrocartilaginous dysplasia is an uncommon disorder that causes a unilateral and progressive tibia vara. These children demonstrate indentation of the medial aspect of the tibia at the junction of the metaphysis and the diaphysis. Bone in this indented area shows dense fibrous tissue and a relatively greater amount of dense lamellar bone. The genu varum usually progresses, but recurrent deformity is uncommon after valgus osteotomy.

Radiographic Classification

In 1952, Langenskiöld described a six-stage radiographic classification of infantile tibia vara that was...
Anteroposterior radiograph of the lower extremities of a two-year and eight-month-old child with hypophosphatemic rickets. Note the widening of the physis, particularly at the "more active" distal femoral and proximal tibial growth plates. The child's height was less than the fifth percentile for age.

Based on changes observed as the child matured (Fig. 5). Stage I, seen in children as old as three years, is characterized by irregular metaphyseal ossification combined with medial and distal protrusion of the metaphysis. Stages II, III, and IV evolve from a mild depression to a definite step-off at the medial aspect of the metaphysis. Increasing inferior angulation of the medial aspect of the epiphysis accompanies depression of the medial aspect of the metaphysis. Stage V demonstrates greater sloping of the medial articular surface and a cleft separating the medial and lateral aspects of the epiphysis. Stage VI has a well demarcated bridge of bone across the medial aspect of the physis.

Langenskiöld's classification has been widely discussed and reproduced in different textbooks, but it is now recognized that this classification has somewhat limited clinical application. In the younger child, it is difficult to differentiate Langenskiöld stage-I tibia vara from physiological bow legs. The metaphyseal-diaphyseal angle is more specific for the diagnosis of infantile tibia vara at an early age.

Original concepts regarding restoration of growth after treatment of patients with infantile tibia vara in the advanced stages of Langenskiöld classification have also been questioned. It was thought that restoration of normal growth occurred routinely after a tibial osteotomy when the radiographic classification was stage IV or less. Subsequent studies in North American children have demonstrated a high percentage of recurrent varus deformity when osteotomies had been performed for the treatment of Langenskiöld stage-III or IV tibia vara. Recurrent deformity has been seen even in children whose radiographs were classified as showing stage-II tibia vara. Langenskiöld subsequently noted that the radiographic stages do not necessarily coincide with prognosis and results of treatment.

The medial physeal slope, an angle formed by the intersection of a line through the lateral aspect of the tibial physis and a line through the medial aspect of the physis (Fig. 6), may be a better radiographic predictor of recurrent varus deformity following osteotomy. In the study by Kling et al., a medial physeal slope greater than 60 degrees was always associated with recurrent varus deformity after tibial osteotomy. Although a larger medial physeal slope correlated with a higher Langenskiöld stage, the medial physeal slope was a more objective measurement and was easier to define.

Orthotic Management

The principle of orthotic management in infantile tibia vara is alteration of abnormal compressive forces...
so that normal growth will resume and the genu varum will be corrected. Bracing does not always accomplish this goal; however, a trial with a brace before the child is three years old does not seem to compromise the results of tibial osteotomy.

Bracing is the treatment of choice for a child fourteen to thirty months old with infantile tibia vara (Fig. 7). Because it takes approximately one year for the physician to know whether brace treatment has been successful, the treatment of the thirty to thirty-six-month-old child should include consideration of other factors. For children of this age, I prescribe an orthosis if the medial physeal slope is less than 50 degrees. I recommend a tibial osteotomy when the medial physeal slope is greater than 60 degrees (Fig. 8). With a medial physeal slope of 50 to 60 degrees, orthotic treatment is selected only after consideration of other elements. Obesity, female gender, and a poor social situation are poor prognostic signs for successful bracing.

The orthosis prescribed for children with infantile tibia vara is an above-the-knee brace with a free ankle, single medial upright, and no hinge joint at the knee (Fig. 9). A cuff around the knee pulls the leg into valgus angulation. A hinge joint at the knee is not needed for sitting activities in these young children. Elimination of the knee joint from the brace makes it easier to align the cuff, makes the brace more adaptable for subsequent growth, and allows easy adjustment of the medial upright. Every six to twelve weeks, the medial upright can be bent to gain further valgus alignment at the knee.

Although some texts recommend only nighttime bracing, I believe that wearing of the brace twenty-two to twenty-three hours a day provides greater potential for correction of infantile tibia vara. In fact, if a child is not able to tolerate full-time brace wear, then the time out of the brace should be while the child is sleeping. Standing and walking increase the compressive, growth-inhibiting forces, and the physis needs protection during these activities.

Because the radiographic parameters that permit early differentiation of physiological bow legs from infantile tibia vara are of recent vintage, the results of orthotic management in infantile tibia vara are still being defined. Early results have indicated that brace therapy for infantile tibia vara is successful in approximately 50 per cent of cases. It is my impression that the results are even better if an above-the-knee brace is worn twenty-three hours a day.
Anteroposterior standing radiograph of the lower extremity of a two-year and six-month-old boy. Even though the patient was relatively young, he was a poor candidate for brace therapy, at least on the left side. The left tibia had a medial physeal slope of 60 degrees. Internal tibial torsion was also evident in the left leg. To make radiographs centered at the knees, the radiology technician frequently externally rotates a leg with marked internal tibial torsion. This makes the fibula appear relatively posterior to the tibia.

Operative Treatment

Osteotomy of the proximal part of the tibia is indicated for the child who is first seen for treatment after age three, for the child thirty to thirty-six months old who is a poor candidate for brace therapy, and for the three-year-old child who has persistent genu varum despite brace therapy. Multiple techniques have been described for the performance of this procedure in children. All involve placement of the osteotomy distal to the tibial tubercle to prevent damage to the tibial apophysis and subsequent genu recurvatum. Concomitant osteotomy of the fibula is necessary to permit adequate correction of the genu varum and internal tibial torsion.

Preoperative assessment before a tibial osteotomy includes judgment of the risk of recurrent varus deformity, a problem that occurs more often than was originally suspected. If the child is at increased risk for recurrent varus deformity, the operation should be altered to diminish that risk. Factors that correlate with recurrent varus deformity include massive obesity, a radiographic classification of Langenskiöld stage III or greater, a medial physeal slope of greater than 60 degrees, and a child who is more than five years old.

Concepts that concern age as a risk factor have changed during the previous decade. Three studies from different centers in the United States have confirmed that children more than five years old with infantile tibia vara have a very high rate of recurrent varus deformity following tibial osteotomy. Ferriter and Shapiro observed a recurrence rate of 76 per cent in children undergoing osteotomy at five years old or older, compared with a 31 per cent recurrence rate in those having operative treatment before that age. Loder and Johnston found that 88 per cent of children less than four years old were successfully treated with one osteotomy, but only 32 per cent of children more than four years old had an adequate result after a single osteotomy. More importantly, the percentage of good results is decreased...
in children who are five years of age or older. This contrasts with the guidelines originally described by Langenskiöld. His data, however, were derived from a homogeneous population of white Finnish children, whereas in the United States the population is more heterogeneous and the majority of children with infantile tibia vara are of the black race and are therefore skeletally more mature.

One possible cause of recurrent varus deformity after tibial osteotomy is an osseous bar bridging the medial aspect of the tibial physis. This physeal bar may not be visible on plain radiographs; therefore, my preoperative evaluation includes two-millimeter thin-slice tomograms on computed tomography scans on patients who have at least one of the following risk factors: (1) an age of five years or older, (2) a medial physeal slope of more than 60 degrees, (3) Langenskiöld stage-IV radiographic changes, (4) body weight greater than the ninety-fifth percentile, (5) a black girl who is close to meeting above criteria, and (6) a medial physeal slope of 50 to 59 degrees in a patient who is close to meeting the criteria just described (Table I).

Unfortunately, the medial aspect of the proximal tibial physis in infantile tibia vara takes a serpentine descending pathway. This can make identification of a physeal bar challenging, even when the radiographic images are adjusted to the plane of the deformity.

If a physeal bridge of bone is identified, then resection of the osseous bar with interposition of fat, methylmethacrylate, or medical-grade elastomer should be considered. Tibial realignment is done at the same operation. Physeal bar resection in infantile tibia vara, however, is difficult and the results are unpredictable (Figs. 10-A, 10-B, and 10-C). The edge of the normal growth plate can be hard to find and the resection may be larger than one would anticipate from the preoperative radiographic studies. In three children with infantile tibia vara undergoing this procedure, Loder and Johnston noted inconsistent results, with one good, one fair, and one poor outcome. An osseous bridge greater than 50 per cent of the width of the growth plate is usually listed as a contraindication to physeal bar excision, but I now restrict physeal bar resection in children with infantile tibia vara to cases in which the osseous bridge occupies less than 30 per cent of the growth plate.

Even with no apparent physeal bar, varus deformity may recur after tibial osteotomy. In this situation, the medial portion of the proximal tibial physis has been meeting the criteria just described, and a probable medial physeal bar showed a probable medial physeal bar.

Fig. 10-A: Anteroposterior radiograph of the left knee.
Fig. 10-B: Anteroposterior radiograph of the left knee three months after bridge resection and realignment osteotomy. The operation was difficult and lasted for seven hours. However, knee alignment was maintained. The right leg was operated on six months later.
Fig. 10-C: Anteroposterior radiograph of both legs, 1.5 years after bridge resection on the right and 2.3 years after bridge resection on the left. Recurrent varus deformity developed in the right leg and the result was considered a failure. Growth and alignment of the left leg were maintained.
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Figs. 11-A, 11-B, and 11-C: Radiographs of a three-year and eight-month-old boy with persistent tibia varA (between Langenskiold stages II and III).

Fig. 11-A: Preoperative anteroposterior standing radiograph. The medial physeal slope measures 61 degrees. The body weight was acceptable, being at the eightieth percentile. The patient was thought to be at some increased risk for recurrent varus deformity.

Fig. 11-B: Anteroposterior radiograph of the leg nine days after a valgus derotation osteotomy. The osteotomy was aligned so that the anatomical knee axis was in increased valgus (17 degrees).

Fig. 11-C: Anteroposterior standing radiograph of both knees at the age of nine years and three months. The over-all alignment was satisfactory, but observation needed to be continued through the remainder of growth.

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abnormally compressed for so long that its growth potential remains limited even after realignment of the tibia. The result is continued overgrowth from the lateral portion of the tibial physis and recurrent genu varum. For children who are at increased risk for recurrent varus deformity but who have no obvious physeal bar (Table I), I modify the operation with one of three techniques: (1) increased valgus alignment of the osteotomy, (2) stapling of the lateral aspect of the tibial physis, or (3) hemiepiphyseodesis of the lateral aspect of the tibial physis and an epiphyseodesis of the proximal part of the fibula. Options 2 and 3 are combined with a realignment tibial osteotomy and are used for more severe problems.

Positioning of the osteotomy in excessive valgus is primarily used in a three or four-year-old child who has increased risk factors for recurrence; that is, obesity, female gender, and an increased medial physeal slope. This position minimizes compression across the disorganized physis and provides time for normal growth to resume. In the best-case scenario, symmetrical growth will resume when the tibia has drifted back into a physiological alignment. The degree of overcorrection is determined according to the surgeon’s judgment, but it is generally 5 to 10 degrees more valgus angulation than is normal for the child’s age (Figs. 11-A, 11-B, and 11-C). Overcorrection should not be done in a child without risk factors, because in such cases a persistent or even increasing valgus deformity can occur. This situation is similar to the valgus deformity that develops after a proximal tibial metaphyseal fracture in a young child.

The child between the ages of five and eight years who does not have a demonstrable physeal bar needs more prolonged protection of the medial portion of the tibial physis. This is particularly true for a girl with a medial physeal slope of greater than 60 degrees or who is massively obese, or both15. In this situation, the tibia is realigned and staples are inserted across the lateral portion of the proximal tibial physis, a concept initially suggested to me by Griffin15. Staples inhibit growth from the lateral aspect of the tibial physis and thereby allow more time for the medial aspect of the physis to recuperate from previous years of abnormal compression. When the tibia starts to demonstrate increased valgus angulation, the staples are removed to allow equivalent growth from both sides of the physis. Initial results with this technique for the older child with infantile tibia vara have been promising, but more experience will be necessary before the success rate of this technique can be
Figs. 12-A, 12-B, and 12-C: Radiographs of a six-year and eleven-month-old morbidly obese girl (weight, 49.8 kilograms—twenty kilograms above the ninety-fifth percentile for age). The tibia vara was Langenskiöld stage IV, and the medial physeal slope was 75 degrees. The patient was at marked risk for recurrent varus deformity. Treatment consisted of valgus derotation osteotomy and stapling of the lateral aspect of the proximal tibial physis. Because of the patient’s size, the osteotomy was fixed with two large, threaded Steinmann pins.

Fig. 12-A: Anteroposterior standing radiograph of the left knee.

Fig. 12-B: Anteroposterior standing radiograph of the knee after injection of radiopaque contrast medium into the knee joint. The medial aspect of the tibial epiphysis shows a large unossified region. Lateral subluxation of the tibia and relative overgrowth of the medial femoral condyle are clearly outlined. The medial meniscus does not appear hypertrophic.

Fig. 12-C: Anteroposterior radiograph of the left knee 1.2 years after a tibial osteotomy. Alignment is well maintained, but the growth plate is closing. The patient was subsequently treated with a contralateral proximal tibial epiphyseodesis, removal of staples, and completion of a left lateral proximal tibial epiphyseodesis. Evaluation prior to the epiphyseodesis revealed an advanced skeletal age (chronological age, eight years; bone age, eleven years). Therefore, ultimate reduction of leg length was expected to be minimum.

determined (Figs. 12-A, 12-B, and 12-C).

Epiphyseodesis of the lateral aspect of the tibial physis and the proximal part of the fibula should be combined with a realignment osteotomy in a child who is first seen at the age of eight or nine years or in a younger child with recurrent varus deformity and a medial physeal bridge that is too large to be resected. In this situation, a contralateral epiphyseodesis should be considered to prevent or correct a leg-length discrepancy.

With advanced changes, the articular surface of the medial tibial plateau is markedly depressed. In these children, an opening wedge osteotomy of the epiphysis should be considered. Langenskiöld reported some good long-term results with the use of this technique in older children who were first seen with a markedly depressed medial tibial plateau. My experience with this procedure is limited to one case. With a five-year follow-up, the result was rated as fair. Relative overgrowth of the medial femoral condyle may limit the success of this procedure (Fig. 12-C).

Neurovascular Complications

The risk of neurovascular complications following a proximal tibial osteotomy is greater in children (Fig. 13) than in adults. Steel et al. initially described this problem when they reported nine cases of neurovascular complications in forty-six children who had undergone proximal tibial osteotomy. As described in this report, the primary symptom was “severe pain in the front of the leg, unremitting and intractable.” Steel et al. attributed the neurological deficits in these children to compression of the anterior tibial artery as it perforated the interosseous membrane, and they recommended immediate repositioning of the leg into varus angulation. These signs and symptoms, however, are also consistent with a compartment syndrome and, in my opinion, this
A child in whom a compartment syndrome developed in all four compartments after a bilateral tibial osteotomy for infantile tibia vara at age eight. The problem was not recognized until the third postoperative day. Compartment releases necessitated closure with skin-grafting. Recurrent varus deformity developed, and muscle recovery was limited to grade-2 strength in the gastrocnemius.

is the most common cause of neurovascular compromise following proximal tibial osteotomy in children.

The anterior compartment is most vulnerable following a realignment operation for infantile tibia vara. This osteotomy is performed distal to the tibial tubercle, and the resultant soft-tissue trauma is the probable cause of this increased susceptibility. I routinely perform a prophylactic subcutaneous release of the anterior compartment fascia at the completion of the tibial osteotomy. Careful and continued postoperative assessment is also necessary. This may be challenging in a young child whose natural apprehension of doctors is enhanced by postoperative pain.

If symptoms and signs of circulatory compromise occur, or if the child is having more pain than expected, the cast should be bivalved and compartment pressures should be measured. A compartment pressure of less than thirty millimeters of mercury calls for continued observation. If the pressure measurements are greater than forty-five millimeters of mercury, the patient is immediately returned to the operating room for fasciotomy. If the compartment pressures are between thirty and forty-five millimeters of mercury, the patient may be observed if examination demonstrates intact neuromuscular function and if no subsequent deterioration occurs.

**Technique of Osteotomy**

I prefer an opening-closing chevron osteotomy in patients who have infantile tibia vara (Figs. 14-A and 14-B). This osteotomy is a modification of the dome osteotomy and has the advantage of providing greater stability and minimum change in leg lengths. The theoretical disadvantage is that a slightly longer period of cast immobilization (approximately two weeks) is needed for incorporation of the wedge segment. This, however, does not cause a problem in children, and the additional period of reduced stress on the medial aspect of the physis may be advantageous. Before the osteotomy is done, paper cutouts are made and a template that
outlines the desired lateral wedge is prepared.

The operation is performed with the patient in a supine position. A sandbag is positioned underneath the ipsilateral hip to facilitate exposure of the fibula. The leg is prepped from the toes to the proximal aspect of the thigh. Prepping of the foot allows more accurate assessment of tibial torsion and permits evaluation of the dorsalis pedis and posterior tibial pulses after the pneumatic tourniquet has been deflated.

The operation starts with osteotomy of the fibula. The middle third of the fibula is exposed via the interval between the lateral and the posterior compartments. The periosteum of the fibula is sharply incised and is circumferentially elevated, with care taken to prevent injury to the adjacent peroneal vessels. A one-centimeter segment of fibula is removed with a reciprocating saw. The fibula is cut obliquely in a superolateral-to-inferomedial direction. This allows the distal portion of the fibula to slide past the proximal fragment as the leg is brought from a varus to a valgus position.

A hockey-stick incision for the tibial osteotomy begins four to five centimeters distal to the tibial tubercle. Staying immediately lateral to the anterior spine of the tibia, the incision extends to the tibial tubercle and then curves in a lateral direction toward the Gurdy tubercle. The periosteum is sharply incised immediately adjacent to the anterior compartment muscles. Immediately distal to the tibial tubercle, the periosteum is transversely incised and then circumferentially elevated so that curved resectors can be positioned to protect the posterior soft tissues. Because of its triangular shape, more care is required at the posterolateral and posteromedial edges of the tibia to ensure that the dissection remains subperiosteal.

The osseous cuts are outlined on the anterior surface of the tibia with an osteotome or cautery. The apex of the osteotomy is immediately distal to the tibial tubercle. An anterior-to-posterior drill-hole is made at this point to minimize the risk of the osteotomy extending beyond the desired location. The osteotomy is completed with an oscillating saw and the lateral wedge is removed.

Depending on the child's age and degree of obesity, as well as the stability of the osteotomy, a single pin, two crossed pins, or no internal fixation may be used (Figs. 15-A, 15-B, and 15-C). Depending on the same factors, I select either smooth or threaded pins. Smooth pins are easier to remove and, in older children, this may be done in the outpatient clinic with the aid of a sedative medication and local anesthesia. In addition, smooth pins should cause less damage if they are inserted across the physis. Threaded pins are easier to insert and have less

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**Fig. 15-A**
Preoperative radiograph.

**Fig. 15-B**
Intraoperative anteroposterior radiograph of the tibia after completion of the opening-closing chevron osteotomy. Alignment was stable, and the single smooth pin used for fixation may not have been needed in this patient.

**Fig. 15-C**
Anteroposterior standing radiograph five years after osteotomy.
of a tendency to loosen but, in children, general anesthesia is usually needed for removal.

If pins are used for fixation, pre-drilling of the diaphysis with small drill-bits makes pin insertion easier and more precise. For the medial pin, a small stab incision is made approximately one centimeter distal to the insertion site. For the lateral pin, the anterior compartment muscles can be retracted enough to allow insertion. Optimum pin position is such that both pins cross the osteotomy site and exit through the proximal cortex without crossing the physis. This pin position, however, is not always necessary. The decision concerning what is acceptable is based on the age of the child and the inherent stability of the osteotomy.

After optimum positioning of the drill-bits at the osteotomy site has been confirmed, the tibia is swung into the desired position of valgus and external rotation. The lateral wedge is inserted medially in a position that will maintain the desired degree of correction. Appropriate size Steinmann pins replace the drill-bits and are driven across the osteotomy site.

The pneumatic tourniquet is deflated and circulation of the foot is assessed. Doppler examination may be necessary. If the circulation is abnormal, the pins are removed and the tibia is restored to its preoperative alignment to eliminate the possibility of compression of the anterior tibial artery. I have never experienced that situation and, as previously noted, I believe that a compartment syndrome is more likely to cause neurovascular compromise after tibial osteotomy in children.

If the circulation is satisfactory, anteroposterior and lateral radiographs of the proximal part of the tibia are obtained to assess osseous apposition, pin position, and tibial alignment. With operating room drapes and a small lower extremity, it may be difficult to include enough of the distal aspect of the femur on the intraoperative radiographs to measure the anatomical knee axis. In this situation, the amount of correction can be assessed by measurement of the “articulodiaphyseal” angle on the preoperative and intraoperative radiographs. This angle is formed by a line drawn tangential to the articular surface of the proximal part of the tibia and a line drawn through the axis of the diaphysis. The difference between the angles on the preoperative and intraoperative radiographs is the degree of valgus correction that has been obtained.

When satisfactory alignment has been confirmed, the Steinmann pins are positioned to facilitate removal and minimize such problems as pin-track infection and skin ulceration. For tibial osteotomies, particularly in obese children, I prefer to bury the pins under the skin rather than leaving them protruding. Smooth pins should be bent and cut to prevent subsequent migration. The pin inserted through the lateral cortex is drilled through the proximal part of the tibia and the overlying skin. This pin is then drilled retrograde until its distal tip is flush with the lateral cortex. The pin inserted through the medial side of the distal part of the tibia is left prominent at its distal end.

Subcutaneous fasciotomy of the anterior compartment is performed with long Metzenbaum scissors. The fascia is incised by pushing of the scissors as far distally as possible, usually to the junction of the middle and distal thirds of the leg. This type of fasciotomy is quickly done, is associated with minimum operative morbidity, and should markedly diminish the risk of compartment syndrome. If possible, the thick periosteum of the tibia is reapproximated to increase the stability of the osteotomy, to decrease hematoma formation, and to enhance bone union. If bleeding from the osteotomy has largely abated, the skin can be closed with a running subcuticular absorbable suture. Otherwise, skin closure should be with interrupted sutures and suction drainage should be utilized.

Closure of the fibular incision starts with inspection of the osteotomy site for possible damage to the peroneal vessels. The fascia is left open but a more extensive compartment release is not performed. The guidelines just described for subcuticular versus interrupted sutures for skin closure are used for this incision as well.

An above-the-knee cast is applied with the knee flexed 45 degrees and the ankle in a neutral posture. Knee flexion relaxes the posterior neurovascular structures and minimizes slippage of the cast in these children, whose limbs are relatively short but often large in circumference. Before the anesthesia is discontinued, radiographs are repeated to confirm that the cast was applied without displacement of the osteotomy.

Young children are allowed only bed-to-chair activities for approximately four weeks. A three to four-year-old child rarely has the coordination and upper body strength to become adept on crutches in this four-week period. For the older child, crutch ambulation is delayed until the fourth to sixth postoperative day. Attempts at ambulation before that time are usually counterproductive, because the operative pain has not abated enough to make therapy sessions effective or efficient. These children are usually discharged from the hospital on the second or third postoperative day, and the therapy sessions are arranged on an outpatient basis.

The cast is changed approximately four weeks after the operation. If radiographs show satisfactory interim healing, the pins are removed and an above-the-knee cast is applied in a position to allow weight-bearing activities. Usually eight to ten weeks of postoperative immobilization is sufficient. Although osteotomies heal faster in children than they do in adults, osteotomies and fractures in children must be protected long enough to minimize the risk of fracture that accompanies a quick resumption of vigorous play activities.

**Recurrent Varus Deformity**

Preoperative and postoperative discussions with the parents should emphasize the need for periodic assess-
ment of the child until growth is completed. Recurrent varus deformity may occur within a relatively short period or it may occur on a delayed basis, particularly during the adolescent growth spurt. In any case, early identification will allow for appropriate treatment before irreversible damage to the articular surface occurs.

If the varus deformity recurs quickly after the osteotomy, I evaluate the patient with computed tomography scans to determine whether a bar of bone is crossing the physis. The decision to do a physeal bridge resection or another procedure is based on guidelines previously discussed. For the older child, the best option is fine-tuning before irreversible damage to the articular surface occurs. For the olden child, the best option is fine-tuning before irreversible damage to the articular surface occurs. The decision to do a physeal bridge resection depends on the degree of varus deformity. A hip-knee-ankle alignment of greater than 10 degrees of mechanical axis will excessively load the anticular surface.

The need for a realignment osteotomy of the tibia in a person who is at or near completion of growth depends on the degree of varus deformity. A hip-knee-ankle mechanical axis of greater than 10 degrees of varus consistently concentrates forces on the medial side of the knee joint and probably predisposes the patient to early osteoarthrosis. Realignment tibial osteotomy is usually recommended for these patients. For the child who has less than 5 degrees of mechanical varus alignment, the joint mechanics are satisfactory and osteotomy is not warranted. At the present time, it is unclear whether a 5 to 10-degree hip-knee-ankle mechanical axis will excessively load the articular surface enough to cause osteoarthrosis at an early age.

**Conclusions**

Infantile tibia vara is a localized disorder of growth secondary to abnormal compression of the medial aspect of the proximal tibial physis. An above-the-knee brace may successfully treat infantile tibia vara in a young child, and a standard tibial osteotomy usually restores normal growth and joint mechanics in a three-year-old child. For an older child with infantile tibia vara, the operative procedure is more complicated and the possibility of a good result is markedly decreased. We must continue to work with primary care physicians and public health nurses so that children with persistent genu varum are evaluated at an early age, preferably before they are two years old.

**References**


