

## COMPREHENSIVE TREATMENT OF COMPLEX TIBIAL DEFORMITIES BY SINGLE-CUT CORRECTIVE OSTEOTOMY

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### Abstract

Complex tibial deformities imply simultaneous correction of varus deformity and internal rotation of the tibia, axis realignment, restoration of joint surface congruity and treatment and prevention of limb length discrepancy. Four patients were treated in our department using the single-cut osteotomy described by Paley. Osteosynthesis was achieved by an external fixator in two cases, K-wires in one case and plate in one case. At follow-up, all patients were satisfied, with normal lower limb alignment and no limb length discrepancy.

**Key words:** tibia vara, single-cut osteotomy, CORA, Blount disease, hypophosphataemic rickets

### Introduction

Limb deformities can be classified according to cause (congenital, developmental, posttraumatic), location (bone or joint contracture, extra- or intraarticular), geometry (angulation, translation, rotation, length discrepancy), severity (magnitude), and progression (static or progressive). Orthopedic surgical correction must consider all of these factors (1).

Limb deformities may lead to dysfunction, pain, and joint degeneration. To patients, appearance may be of primary concern. For bone deformities, the mainstay of treatment has been osteotomy, whereas for joint-contracture deformities, extra- and intraarticular soft-tissue releases have been the standard of treatment (1).

Many innovative osteotomies have been developed to treat limb deformities. The results are frequently subjectively acceptable but objectively inaccurate. Secondary deformities often result from primary correction. The significance of this has only recently been recognized (2;3). Inaccuracy of correction in children has often been excused by the time-honored pediatric orthopedic motto, "It will remodel with time." In some cases, this has been true. In many cases, however, residual and secondary translation and angulation deformities have gone untreated into adult life. Although most of these residual and secondary deformities are asymptomatic in children, many lead to degenerative changes and disability in adults. During the 20th century, high postoperative complication rates were often reported: neurovascular complications owing to acute correction with stretch injury and compartment syndromes (4) and bone complications owing to extensive exposure and methods of fixation. During the last 10 years of the

20th century, a revolution occurred in the management of children's deformities because of improved biologic and mechanical techniques.

Gradual correction reduces the operative exposure needed to cut the bone (5). Acute surgical morbidity is greatly reduced by these percutaneous techniques. Furthermore, progressive correction avoids stretch damage to the neurovascular structures that are at risk. The magnitude of correction, which was previously the limiting factor in how much deformity correction could be achieved, is no longer an obstacle with gradual correction of bone or joint deformities. The accuracy of correction, which was usually only +/-5°, improved greatly (6) with gradual correction because of postoperative adjustability of external fixation.

With the advent of radiographs just over 100 years ago, our understanding of the geometry of deformities increased greatly. A wide variety of configurations of osteotomy were developed to correct these deformities. The most commonly used have been the opening and closing wedge osteotomies and the dome osteotomy (1).

Despite improvements in imaging techniques and methods of internal and external fixation, the study of the geometry of deformities remained greatly unexplored until the past 10 years. The level of the apex of deformity was always considered intuitively, and the level of osteotomy relative to the apex depended on the location of the physis and the space needed for the hardware. This approach more often than not created secondary translation deformities. Paley et al. (2;3) described the concept of the center of rotation of angulation (CORA). They demonstrated that when the axis of correction and the osteotomy are at a level different from that of the CORA, secondary translation deformities occur. They developed a simple method to identify rapidly and accurately the level of the CORA. Because the concepts of the CORA and the axis of correction are basic principles of deformity correction, they are independent of the method of fixation used. Although in the past, the tendency has been to make the osteotomy accommodate the fixation, the current concept is to consider the principles of deformity correction as preeminent and to make the fixation and osteotomy adhere to the principles. In other words, instead of osteotomy being slave to fixation, fixation becomes slave to osteotomy. With this approach, we can eliminate secondary deformities after osteotomy (1).

A more recent development has been to harness the capriciousness of the physis by temporary hemiepiphyseal stapling (7). Epiphyseal stapling was a popular method for treating angular deformities in adolescence during the 1960s and 1970s. It became less popular as osteotomy techniques improved during the 1980s and 1990s. Stevens et al. (8) recently showed that it is a safe technique to use in young children, with little risk of growth plate closure.

**Purpose**

Tibia vara can be difficult to treat because of frequent associated deformities, including distal femoral varus, proximal tibial procurvatum and distal tibial valgus that contribute to lower limb malalignment. We present a comprehensive approach that addresses all components of

the deformity and allows restoration of the anatomic and mechanical axes.

**Materials and methods**

Five limbs in four patients presenting with tibia vara were operated on between 2004 and 2005. There were three girls and one boy. Average age at surgery was 8 years 6 months. The diagnosis at initial presentation was: vitamin D-resistant hypophosphataemic rickets (VDRR) in two cases, Blount’s disease in one case and genu varum post septic osteoarthritis of the knee in one case (Table 1). Two patients had previously undergone two valgus osteotomies each.

Patients were analyzed clinically and radiologically according to leg axis and length, knee mobility and stability and pain.

Table 1. Synopsis of patients

<i>Pt. No.</i>	<i>Age at surgery</i>	<i>Sex</i>	<i>Diagnosis</i>	<i>No. of previous osteotomies</i>	<i>Varus</i>	<i>Internal rotation</i>	<i>Procurvatum</i>	<i>LLD</i>
1.	14 yrs	F	VDRR	2	16 <sup>0</sup>	0	32 <sup>0</sup>	0
2.	3 yrs	M	Blount’s disease	0	30 <sup>0</sup> (R) 30 <sup>0</sup> (L)	40 <sup>0</sup> (R) 35 <sup>0</sup> (L)	0	0
3.	7 yrs	F	Genu varum post septic osteoarthritis of the knee	0	20 <sup>0</sup>	43 <sup>0</sup>	0	6 cm
4.	10 yrs	F	VDRR	2	20 <sup>0</sup>	30 <sup>0</sup>	0	0

VDRR --vitamin D-resistant hypophosphataemic rickets; LLD --limb length discrepancy

Preoperative planning

Angular deformity of the tibia involves angulation not only of the bone but also of its axes.

We calculated the amount of deformation using the Paley et al. method. The point at which the proximal and distal axis lines intersect is called the center of rotation of angulation (CORA). The axis line of the proximal bone segment is called the proximal mechanical axis (PMA) or proximal anatomic axis (PAA) and the axis line of the distal bone segment is called the distal mechanical axis (DMA) or distal anatomic axis (DAA) (9).

We draw the PMA or PAA and the DMA or DAA lines and identified the CORA at their points of intersection. We measured the magnitude of angulation in the frontal plane.

When rotation and angulation deformities are both present, the axis of rotation and the axis of angulation can be defined as two separate axes or can be resolved into one axis that defines both deformities. The axis of angulation is

in the transverse plane. The axis of rotation is the longitudinal axis that is perpendicular to the transverse plane. That axis that defines both angulation and rotation is inclined between the longitudinal and the transverse axes of rotation and angulation, respectively (9).

We calculated the orientation of this longitudinally inclined axis using a modification of the graphic method.

Operative technique

The first step is a 2-cm segmentary resection of the fibular diaphysis at the junction between the middle and lower third.

We then expose the anteromedial aspect of the tibial metaphysis or diaphysis at level of the determined CORA.

Combined torsional and angular deformities of the tibia are corrected creating a single osteotomy which is oriented so that rotating the two fragments on the created osteotomy plane allows to correct all deformities in one step (Fig. 1).



Fig. 1. The orientation of the osteotomy plane.

*Patient 1*

A 14 years old girl presented with vitamin D-resistant hypophosphataemic rickets (VDRR), for which she underwent two valgisation/derotation osteotomies on the left side. On the left side she had 16° varus deformity and 32° procurvatum of the tibia. She had no limb length discrepancy. Radiographs showed 16° varus deformity in the frontal plane and 32° procurvatum deformity in the

sagittal plane. 30° oblique radiograph showed no deformity of the tibia (Fig. 2). We performed the correction osteotomy in the transverse plane, inclined 30° from the sagittal plane. The stabilization of the osteotomy was obtained by an external fixator. The fixator was removed 3 months postoperatively. No pin-site infection was observed. At 1 year follow-up, the patient had normal leg alignment, no limb length discrepancy and no pain (Fig. 3).

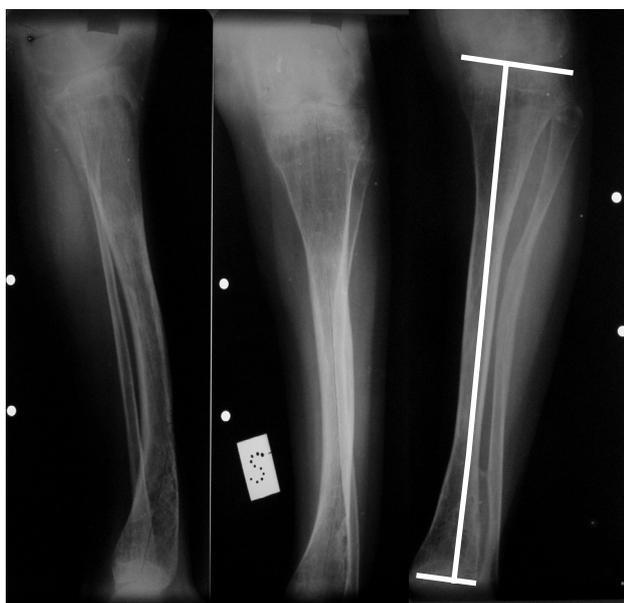


Fig. 2. Patient 1: 32° procurvatum deformity in the sagittal plane, 16° varus deformity in the frontal plane and no deformity in the 30° oblique plane.

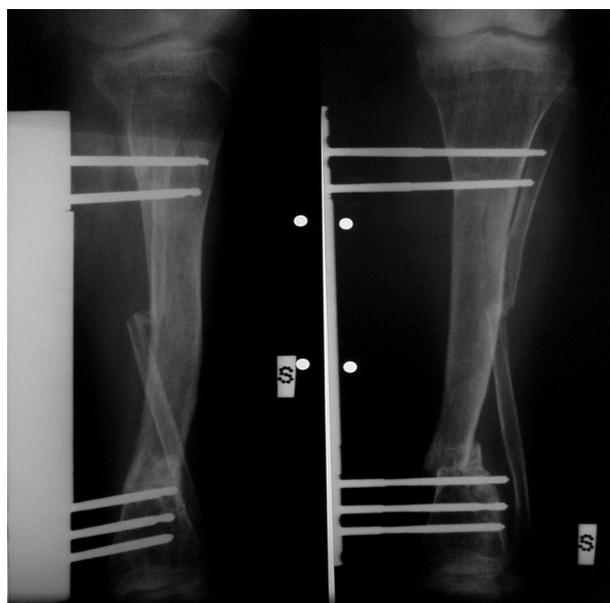


Fig. 3. Patient 1: Postoperative appearance.

*Patient 2*

A 3 years old boy presented with bilateral Blount's disease (Fig. 4). He had 40° internal rotation and varus deformities on the right side and 35° internal rotation and varus deformities on the left side. Radiographs showed 30° metaphysodiaphyseal angle (MDA) on both

sides. We performed a single-cut osteotomy on the left side and then on the right side, followed by percutaneous K-wires fixation and long leg plaster cast immobilization for 6 weeks. At plaster cast removal we removed the K-wires also. At follow-up the boy had normal leg alignment (Fig. 5).



Fig. 4. Patient 2: Bilateral Blount's disease, operated on the left side.

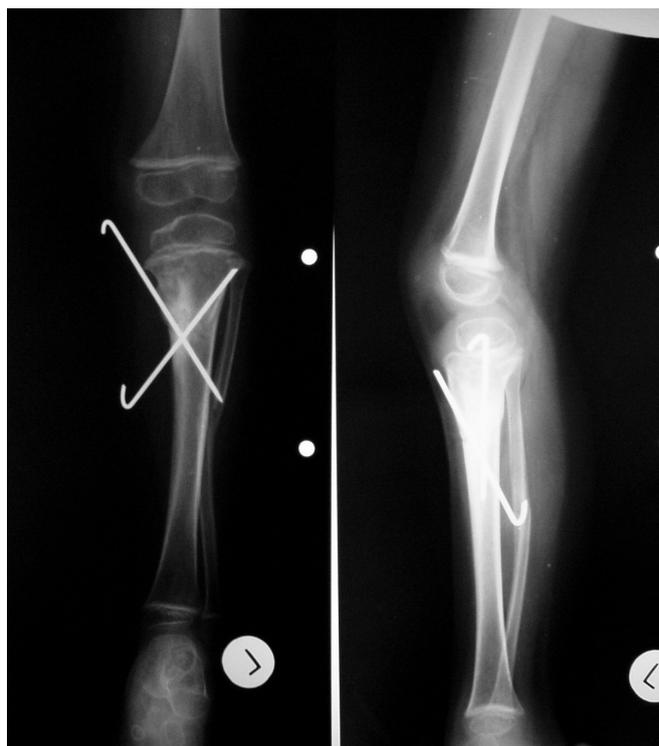


Fig. 5. Patient 2: normal tibial alignment on the left side postoperatively.

*Patient 3*

A 7 years old girl was examined in 2004 for left side  $20^{\circ}$  varus,  $43^{\circ}$  internal rotation and 6 cm limb length discrepancy following septic growth arrest of the proximal tibia (Fig. 6). We performed single-cut osteotomy, fixed by external fixator which allowed us to make the lengthening

of the tibia. Oral antibiotics were used to treat a pin-site infection. The fixator was removed after 8 months postoperatively. At 1 year follow-up the patient had normal leg alignment, no limb length discrepancy and fixed extension contracture of the left knee (because of initial septic osteoarthritis of the knee) (Fig. 7).

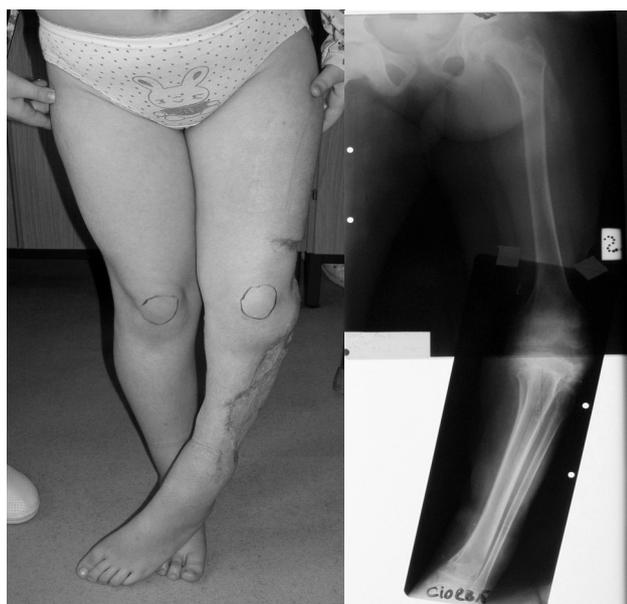


Fig. 6. Patient 3:  $20^{\circ}$  varus,  $43^{\circ}$  internal rotation and 6 cm limb length discrepancy following septic growth arrest of the proximal tibia.



Fig. 7. Patient 3: At follow-up normal leg alignment, no limb length discrepancy.

*Patient 4*

A 10 years old girl presented with VDRR for which she underwent two valgisation osteotomies on the left side. On the left side she had 20° varus and 30° internal rotation deformities of the distal tibia (Fig. 8). We

performed single-cut osteotomy in the lower third of the tibia, fixed with a 4-holes plate. The union was obtained after 2 months, with normal leg alignment and no pain (Fig. 9). The hardware implant was not removed yet.



Fig. 8. Patient 4: 20° varus and 30° internal rotation deformities of the tibia.



Fig. 9. Patient 4: the union was obtained after 2 months, with normal leg alignment and no pain.

**Results**

Average follow-up was 8 months. Average preoperative varus deformity was 23,2° versus 3,5° after correction. Average preoperative internal rotation was 29,6° compared to 1,8° postoperatively.

The fixation hardware was left in place for an average of 6 weeks, allowing a longer period (8 months) for the patient who required limb lengthening.

The patients were satisfied and had no residual deformities. Radiographically, all patients had correct alignment and articular congruency.

We had only one complication: pin-site infection requiring oral antibiotics.

**Discussions**

Blount's disease is characterized by progressive varus deformity of the proximal tibia associated with internal rotation of the tibia. It is caused by a growth disorder of the medial portion of the medial tibial physis. The turning point in the evolution of the disease is the development of a metaphysoepiphyseal bony bridge of the medial proximal tibia (10). It is widely accepted that early treatment diminishes the recurrence rate of Blount's disease (11;12).

If performed before age 4 to 5 years, the rate of recurrence following valgisation is low, hence improving the long-term prognosis (11;12). However, we are sometimes confronted with advanced recurrent disease with several deformities to deal with. The prerequisite for treatment is evaluating the magnitude of all tibial deformities. Using the Paley's method of preoperative planning, we are able to evaluate and correct all deformities in one step avoiding secondary deformations due to osteotomy. Lower limb frontal and sagittal plane alignment and joint orientation have significant consequences for function and wear on the hip, knee and ankle. There is a normal range for the orientation of these joints relative to the mechanical and anatomic axis of the femur and/or tibia. We can use the normal joint orientation to accurately plan realignment of a deformed femur or tibia. In the frontal plane we use both anatomic and mechanical axis lines for planning. In the sagittal plane, the mechanical axis has less relevance and, therefore, only the anatomic axis is used for planning (9).

Monticelli and Spinelli (13) described four cases of one-step surgical procedure using an Ilizarov device to treat several deformities.

It is widely accepted that genu varum encourages femorotibial medial arthrosis. Depression of the medial

tibial plateau increases joint incongruity. Zayer (14) found 7 cases of knee arthritis in a population of 17 patients aged 30 to 60 with juvenile Blount's disease. Doyle et al (11) found 6 cases of arthritis in a series of 17 patients aged 16 to 35 years. Ingvarsson et al (15) found, in 49 patients followed to adult life (average 38 years old), 11 cases of knee arthritis in 8 patients and 15 cases of knee surgery in adulthood (10 meniscectomies, 4 valgisation osteotomies, 1 total knee prosthesis).

The majority of authors recommend correction of all deformations in one-step surgical procedure.

Single-cut osteotomy is an innovative technique developed by Paley et al. We use single-cut osteotomy for correction of complex tibial deformity in each case.

### Conclusions

One-step surgical management of the complex tibial deformities is an original technique that results in a decrease in both hospital stay and the number of operations. For these reasons, it could be classified as a minimal invasive procedure. This, however, does not eliminate the need for regular follow-up; this type of treatment requires full patient and family collaboration.

This comprehensive approach allow restoration of the mechanical and anatomic axes of the lower limb in patients with tibia vara, resulting in a resolution of symptoms as a result of normalization of the weight-bearing forces across the knee and ankle. We believe that this approach will decrease the risk of early degenerative arthritis of the knee.

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