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FEMORAL DEFORMITY IN TIBIA VARA

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Background: Previous studies have suggested that compensatory valgus deformity of the femur is common in patients with tibia vara, or Blount disease. The availability and routine use of standing long-cassette radiographs of the lower extremities to assess angular deformities has allowed quantitative evaluation of this hypothesis.

Methods: The cases of all patients with tibia vara, two years of age or older, seen at our institution prior to treatment, over a thirteen-year period, were reviewed. Seventy-three patients with a total of 109 involved lower limbs were identified and were classified as having either infantile tibia vara (thirty-seven patients with fifty-six involved limbs) or late-onset tibia vara (thirty-six patients with fifty-three involved limbs). Standardized standing radiographs of the lower extremity were examined to assess the deformity at the distal part of the femur and the proximal part of the tibia by measuring the lateral distal femoral angle and the medial proximal tibial angle.

Results: The distal part of the femur in the children with infantile tibia vara either was normal or had mild varus deformity, with a mean lateral distal femoral angle of 97° (range, 82° to 129°). The mean medial proximal tibial angle in these children was 72° (range, 32° to 84°). Older children with infantile tibia vara were noted to have little distal femoral deformity, with no more than 4° of valgus compared with either normal values or the contralateral, normal limb. Children with late-onset tibia vara had a mean lateral distal femoral angle of 93° (range, 82° to 110°) and a mean medial proximal tibial angle of 73° (range, 52° to 84°). On the average, the varus deformity of the distal part of the femur constituted 30% (6° of 20°) of the genu varum deformity in these patients.

Conclusions: Patients with infantile tibia vara most commonly had normal alignment of the distal parts of the femora; substantial valgus deformity was not observed. Distal femoral varus constituted a substantial portion of the genu varum in children with late-onset disease. When correction of late-onset tibia vara is planned, the surgeon should be aware of the possibility that distal femoral varus is a substantial component of the deformity.

Tibia vara, or Blount disease, is a complex deformity that can be difficult to correct¹⁻¹⁷. Treatment recommendations have focused on the tibial deformity. Less severe deformities in older children and in adolescents with open physes have been treated successfully with hemiepiphyseodesis or hemiepiphyseal stapling^{7,18-21}. The most severe deformities in children with neglected infantile tibia vara require osteotomy with or without elevation of the medial tibial plateau^{2,12-14,22,23}. More severe deformities or deformities in patients with little or no remaining growth require osteotomy combined with internal or external fixation^{1,3,5,6,8-11,15,17,22,24-27}.

Femoral deformity has long been noted in patients with tibia vara, and this has complicated the treatment^{13,23,28-34}. Infantile tibia vara has been associated with overgrowth of the medial condyle of the femur, resulting in a valgus deformity of the distal part of the femur^{13,23,29,30,33-35}. Late-onset tibia vara has been associated with both varus and valgus deformity of the distal part of the femur^{13,29,33,35,36}.

Recently, the use of standardized long-cassette radio-

graphs and analysis of the mechanical axis have become the standard for assessing lower-extremity deformities^{37,38}. The establishment of standard positioning and radiographic techniques has allowed much more exact assessment of complex deformities, particularly tibia vara, than was possible previously³⁷⁻⁴⁰. At our institution, we have routinely utilized this method of evaluating children with angular deformities of the lower extremity, including tibia vara, since 1990. We have found that careful measurement of each of the constituent deformities is essential to correct these deformities accurately. The purpose of this study was to evaluate, with use of standardized long-cassette radiographs, the distal femoral alignment in patients with different forms of tibia vara and to characterize these deformities.

Materials and Methods

The charts and radiographs of all patients treated for tibia vara at our institution between January 1, 1990, and December 31, 2002, were retrospectively reviewed. The charts

were reviewed for demographic data, and patients were classified as having early-onset, or infantile, tibia vara if the age at onset was three years or younger and as having late-onset tibia vara if the age at onset was four years or older. Late-onset disease was further classified as either juvenile (age at onset, four to ten years) or adolescent (age at onset, eleven years or older)^{1,41}. Patients treated previously with femoral surgical intervention or bracing and those in whom the tibial deformity had resolved prior to presentation at our institution were excluded from the study. The immediate pretreatment standing anteroposterior radiographs were examined, and the lateral distal femoral angle (normal average, 88°; normal range, 86° to 90°) and the medial proximal tibial angle (normal average, 87°; normal range, 85° to 89°) were measured (Fig. 1)^{37,38}. These measurements were selected because they characterize the osseous deformity about the knee in the distal part of the femur and the proximal part of the tibia. The radiograph was made with the patient standing and positioned with the distal part of the femur presenting in an anteroposterior view (the contour of the femoral notch was normal, and the patella was facing directly anterior³⁹). When the contralateral side was noted to be normal and was included on the radiographs, the lateral distal femoral angle and the medial proximal tibial angle were measured as controls.

Seventy-three patients, with a total of 109 involved limbs, who had tibia vara and standing anteroposterior radiographs of the lower extremity made prior to treatment were identified. Thirty-seven patients with a total of fifty-six involved limbs had infantile tibia vara: nineteen of them (thirty-eight extremities) had bilateral involvement, and eighteen had unilateral involvement. The thirty-seven patients with infantile tibia vara had a mean age of 4.9 years (range, 2.0 to 12.5 years) at presentation, and the nineteen patients with unilateral early-onset disease had a mean age of 4.4 years (range, 2.0 to 9.2 years).

Thirty-six patients with a total of fifty-three involved limbs had late-onset tibia vara. Thirteen of them (seventeen involved limbs) had juvenile tibia vara, and twenty-three (thirty-six involved limbs) had adolescent tibia vara. Seventeen of the thirty-six patients with late-onset disease had bilateral tibia vara, and nineteen had unilateral tibia vara. The mean age at presentation was 13.8 years (range, 8.2 to 18.2 years) for the thirty-six patients with late-onset tibia vara and 13.0 years (range, 10.2 to 18.2 years) for the nineteen patients with unilateral late-onset disease.

Results

Infantile Tibia Vara

The fifty-six involved limbs in the thirty-seven patients with infantile tibia vara had a mean lateral distal femoral angle of 97° (range, 82° to 129°). Only two patients with infantile tibia vara, who were 5.7 and 7.5 years old at the time of presentation, had a lateral distal femoral angle of <85°, and neither angle was <82°. Thirty (54%) of the fifty-six limbs with infantile tibia vara had a lateral distal femoral angle of ≥93° (≥5° of varus deformity), and twenty-two had a lateral distal femoral angle of ≥98° (≥10° of varus deformity). The

lateral distal femoral angle decreased with increasing age at the time of the evaluation, changing from a more varus alignment toward a normal to slightly valgus alignment in the older patients (Fig. 2). The mean medial proximal tibial angle was 72° (range, 32° to 84°). There was no substantial change in the medial proximal tibial angle with increasing age at the time of evaluation (Fig. 3).

Fig. 1
Coronal plane illustration of the lower extremity, demonstrating measurement of the lateral distal femoral angle (LDFA) and the medial proximal tibial angle (MPTA).

Fig. 2

Lateral distal femoral angle compared with age at the time of the evaluation in patients with infantile tibia vara.

The eighteen patients with unilateral infantile tibia vara had a mean lateral distal femoral angle of 99° (range, 83° to 116°). The mean lateral distal femoral angle on the contralateral, normal side in these patients was 96° (range, 86° to 115°). The mean difference in the lateral distal femoral angle between the control and involved sides was 3° (range, -4° to +18°), representing slightly more varus of the femur of the involved extremity. The lateral distal femoral angle of the involved extremity was in more valgus than that of the contralateral extremity in

six patients, but this difference was as much as 4° in only two patients. No patient had >4° of valgus angulation of the distal part of the femur compared with the contralateral, normal side.

The eighteen patients with unilateral infantile tibia vara had a mean medial proximal tibial angle of 74° (range, 43° to 84°), with a mean of 89° (range, 79° to 95°) on the contralateral, normal side and a mean difference between the normal and involved sides of 14° (range, 3° to 38°), representing more varus in the involved extremity.

Fig. 3

Medial proximal tibial angle compared with age at the time of the evaluation in patients with infantile tibia vara.

Fig. 4

Lateral distal femoral angle compared with age at the time of the evaluation in patients with late-onset tibia vara.

Late-Onset Tibia Vara

The fifty-three involved limbs in the thirty-six patients with late-onset tibia vara had a mean lateral distal femoral angle of 93° (range, 82° to 110°). Twenty-nine (55%) of the fifty-three involved limbs had a lateral distal femoral angle of $\geq 93^\circ$ ($\geq 5^\circ$ of varus deformity), and ten (19%) had a lateral distal femoral angle of $\geq 98^\circ$ ($\geq 10^\circ$ of varus deformity). Although there was no substantial change in the lateral distal femoral angle with

increasing age, distal femoral varus was seen in all age groups (Fig. 4). The nineteen patients with unilateral late-onset tibia vara had a mean lateral distal femoral angle of 95° (range, 82° to 106°), with a mean of 87° (range, 83° to 92°) on the contralateral, uninvolved side and a mean difference between the involved and uninvolved sides of 8° (range, -2° to $+21^\circ$), representing more varus in the distal part of the femur of the extremity with tibia vara. On the average, the varus deformity of

Fig. 5

Medial proximal tibial angle compared with age at the time of the evaluation in patients with late-onset tibia vara.

Fig. 6
Standing anteroposterior radiograph of the left lower extremity of a fourteen-year-old boy with late-onset tibia vara and apparent distal femoral valgus. The lateral distal femoral angle measures 91° , representing slight distal femoral varus.

the distal part of the femur constituted 30% (6° of 20°) of the genu varum deformity in these patients.

The mean medial proximal tibial angle in the patients with late-onset tibia vara was 73° (range, 52° to 84°). There was no substantial change in the medial proximal tibial angle with increasing age (Fig. 5). The nineteen patients with

unilateral late-onset disease had a mean medial proximal tibial angle of 74° (range, 52° to 81°), with a mean of 88° (range, 84° to 93°) on the contralateral side and a mean difference of 14° (range, 7° to 38°) between the normal and control sides, representing more varus in the tibia of the involved extremity.

Fig. 7
Standing anteroposterior radiograph of the left lower extremity of a thirteen-year-old boy with late-onset tibia vara and an apparently normal distal part of the femur. The lateral distal femoral angle measures 100° , representing substantial distal femoral varus.

Discussion

In an assessment of lower-extremity deformity, care must be taken to measure, on a reproducible radiograph, each of the contributing deformities. In the past, radiographs of the knee or longer non-standardized radiographs were used to assess deformity in patients with tibia vara^{13,30,32,42-44}. Non-standardized radiographs of the knee or a portion of the lower extremity do not allow the full assessment of deformities that is possible with a review of a long-cassette radiograph made with proper positioning. A long-cassette radiograph can reveal the true contribution of femoral deformity to the overall deformity. It had been assumed that proximal tibial varus was the only substantial deformity in tibia vara. In reality, tibia vara is often a complex deformity that includes distal femoral deformity, proximal tibial varus and procurvatum, internal tibial torsion, and distal tibial deformity^{23,29,32,36,45-47}. These other deformities cannot be ignored when a global strategy is being planned for correction of severe tibia vara. Kline et al. measured the distal femoral component on standardized radiographs of patients with late-onset tibia vara and reported that the distal femoral varus deformity was often as great as the proximal tibial varus deformity²⁹. All of the six patients in that study had $\geq 5^\circ$ of distal femoral varus compared with the normal value.

Persistent distal femoral deformity did not develop in the children with infantile tibia vara in our series. Children with infantile tibia vara who were seven years of age or younger were often observed to have varus in the distal part of the femur, but this deformity seemed to disappear gradually with increasing age (Fig. 2). In older children with residual infantile tibia vara, the distal part of the femur tended to have a normal to slightly valgus mechanical alignment. Valgus deformity was noted in two older children with early-onset tibia vara, but it was mild (never $>4^\circ$).

Our data further suggest that the distal femoral mechanical axis in children with late-onset tibia vara is always in neutral to varus alignment. Often, the distal femoral varus deformity contributes substantially to the overall genu varum²⁹. We did not observe substantial valgus deformity in any patient with late-onset tibia vara. However, ten (19%) of the fifty-three extremities with late-onset disease had $\geq 10^\circ$ of varus deformity, a factor that should be taken into account when surgical correction is being planned. Failure to account for the femoral deformity, when it is substantial, could lead either to undercorrection of the entire deformity or to excessive compensatory correction of the tibia with resulting obliquity of the knee joint.

One possible reason for the widespread belief that patients with severe tibia vara have distal femoral valgus deformity is the appearance of valgus on radiographs of the knee. Most orthopaedic surgeons interpret distal femoral deformity on the basis of how parallel the knee joint is to the floor. If the knee joint appears to be parallel to the floor, then the distal part of the femur appears normal. If, however, the medial femoral condyle appears to be more distal than the lateral femoral condyle, with a resulting downward medial joint

slope, the distal part of the femur is interpreted as having a valgus deformity. In tibia vara, the proximal tibial varus deformity prevents the patient from bringing the knees together in stance. This produces relative hip abduction during stance that leads to an anatomically normal distal part of the femur with an appearance of substantial valgus on anteroposterior radiographs (Fig. 6). In the same way, patients with a substantial genu varum deformity with distal femoral varus can appear to have normal distal femoral alignment because the relative abduction of the hip seems to correct the alignment of the distal part of the femur, placing the knee joint parallel to the floor (Fig. 7). Therefore, varus and valgus changes of the distal part of the femur cannot be accurately assessed by simple visual inspection of either a knee radiograph or even a long-cassette radiograph. It is imperative that long-cassette radiographs be made with the limb in proper alignment when definitive correction is being planned for patients with tibia vara and that angular measurements be performed to assess the true amount of distal femoral deformity^{37,38}.

Our data suggest that distal femoral valgus is seldom present in tibia vara, except in severe, neglected cases of early-onset disease. Valgus deformity is often more apparent than real in patients with tibia vara, and we believe that varus distal femoral osteotomies are rarely justified, except for older children with severe neglected disease.

In conclusion, we found valgus changes in the distal part of the femur in patients with infantile tibia vara to be small and that patients with the appearance of valgus on radiographs often do not have a true deformity. Patients with late-onset tibia vara were found to have varus changes in the distal part of the femur, and the femoral component often represented a substantial portion of the genu varum deformity. ■

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