GROWTH DISTURBANCE LINES AFTER INJURY OF THE DISTAL TIBIAL PHYSIS

THEIR SIGNIFICANCE IN PROGNOSIS

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We reviewed 26 fractures involving the distal physis of the tibia to identify the patterns of formation and displacement of the subsequent growth disturbance lines. Twenty-one patients showed a regular "normal" pattern of line and healed with no deformity. Three patients had medial physeal arrest revealed by abnormal lines. Two other cases had a minor central physeal arrest without subsequent deformity.

The pattern and character of the growth disturbance line can provide an early warning of potential deformity.

Transverse lines of increased radiographic density in the metaphyses of long bones have been recognised for over 100 years. They are sometimes termed Harris lines (1933) but are best described as growth disturbance lines (O'Brien 1985). They are dense because of increased thickness of trabecular bone and initially appear as sclerotic lines at the metaphyseal-physeal junction. As physeal growth continues the physis grows away from the line.

Carlson and Wenger (1984) have mapped the cross-section of the distal tibial physis. This allows visualisation of the physis not as a two-dimensional radiolucency but as a plate-like structure, which can be divided into sections, each of which contributes to overall growth. If growth ceases in one area, the effect will depend on the site and extent of the area, as well as the age of the child at the time of injury (Karrholm, Hansson and Svensson 1983).

Growth disturbance lines are associated with episodes of illness or injury in childhood and adolescence. The association with trauma is well known; lines appear after shaft fractures in the long bones of children. Fractures of the main lower limb bones cause growth disturbance lines to appear in both the fractured and the contralateral limb (Garn et al. 1968), and indeed at all the fast-growing physis (see Fig. 10).

Only recently has the use of these lines to indicate the condition of a physis been described (O'Brien, Millis and Griffin 1986). In this paper we describe the growth disturbance lines which appear in the distal tibia after physeal fractures and assess their usefulness as prognostic indicators.

PATIENTS AND METHODS

We reviewed the records and radiographs taken at regular intervals of 26 patients who presented to The Children's Hospital in Dublin with fractures involving the distal tibial physis from January 1982 to December 1985. The following features were noted:

1. The time interval between the injury and the appearance of the growth disturbance line.
2. The subsequent displacement of the physis from this line.
3. The appearance of the line on successive radiographs with reference to the eventual outcome in terms of deformity.

The appearance was compared with that of the contralateral tibia when radiographs were available.

RESULTS

In all there were 18 Salter–Harris Type II and eight Type III fractures in patients whose ages ranged from 7 to 15 years. There were 15 boys and 11 girls.

In 21 patients there was a regular pattern of formation and displacement of the growth disturbance line at the injured physis. Six weeks after the fracture a sclerotic margin at the metaphyseal-physeal junction was visible in 16 patients while in five cases a sclerotic line had already become separated from the physis by at least 1 mm. The sclerotic line extended across the full width of the tibia and appeared to be more dense in the centre. It was identifiable on both the anteroposterior and lateral views, and its immediate development appeared to be independent of the age of the patient.
Figure 1 - Three months after a Salter-Harris Type II injury of the distal tibial physis there is a sclerotic line which is displaced from the physis but remains parallel to it. Figure 2 - One year later there is continued normal growth.

Case 1 (see text for details). Radiographs of the injured side at presentation, after six weeks and three months, and of both ankles at maturity.

Case 2. Figure 7 - Radiograph of the severe initial injury. Figure 8 - At operation an island of physis remains attached to the metaphysis. Figure 9 - After six weeks, the growth disturbance line is seen as a sclerotic margin to the metaphysis in both ankles. Figures 10 and 11 - Displacement continues parallel to the physis, and in the final film the central part of the line is missing (arrowhead), indicating that there had been a small area of growth arrest.
Subsequently, growth resulted in displacement of the physis from the line. By 12 weeks the lines in all 21 patients had separated from the physis (Fig. 1). The rate of this displacement was greater in the injured tibia than in the contralateral uninjured leg, and during this period the distal tibial physis grew at a faster rate than the proximal tibial physis of the same leg. This is a temporary reversal of the normal difference. In all 21 patients the line remained parallel to the physis and no deformity developed (Fig. 2).

In the other five patients the normal formation and displacement of the line did not occur; subsequently all these patients had abnormal growth. In three of them a peripheral area of the distal tibial physis was damaged; this resulted in varus angulation from the continued unbalanced growth of the lateral part of the physis. In these cases the growth disturbance line could be seen to be abnormal by 12 weeks after the injury.

Case 1. A 10-year-old girl presented with a Type III fracture (Fig. 3). Open reduction was performed and the fracture was fixed temporarily with two K-wires. The radiograph at six weeks (Fig. 4) already shows a normal response in the lateral part of the physis, but the sclerotic line is missing from the medial side. After three months the growth disturbance line still had not appeared medially (Fig. 5). This physeal arrest went unrecognised and at the age of 14 years the patient presented with an established deformity (Fig. 6). Though the physis had closed the incomplete growth disturbance line was still visible.

Two patients showed signs of a small central area of arrest of the distal tibial physis.

Case 2. A nine-year-old girl sustained a severe fracture (Fig. 7). At open reduction a small part of the physis could be seen to remain attached to the metaphysis (Fig. 8); it is therefore avascular. Follow-up radiographs demonstrate a corresponding gap in the middle of the growth disturbance line (Figs 9 to 11). This marks an area of growth arrest, but the area involved was too small to cause any significant growth retardation. In comparison with the opposite side, there has been relatively more growth.

**DISCUSSION**

Impairment of growth after fractures which involve the distal tibial physis may cause a length discrepancy, an angular deformity, or both (Ogden 1982). Injuries to the distal tibial physis tend to occur in older children so gross discrepancy in leg length is not common. Closure of the periphery of the physis will result in a tilt deformity of the ankle, and it is important that these partial arrests are identified early and accurately. We suggest that the site of any physeal arrest can be accurately determined from analysis of the character and displacement of growth disturbance lines. It has been said in the past that up to 18 months may elapse before growth arrest can be diagnosed and that all patients with fractures having this potential should be followed to maturity (Kling, Bright and Hensinger 1984).

After a fracture, the sclerotic line of growth disturbance first appears after 6 to 12 weeks. If the line extends across the whole width of the metaphysis in both planes, then it is likely that the entire physis will continue to grow. The line should be studied for focal defects; these may indicate areas of growth impairment. If the physis remains parallel to the line, then angular deformity will not follow. There is usually some growth stimulation in the first 4 to 6 months after injury; when this is greater on the fractured side (see Fig. 10), the prognosis for a normal result is good.

A "normal" growth disturbance line appears to be more sclerotic towards the centre of the bone on both anteroposterior and lateral views. Radiographs of the line are two-dimensional representations of a disc and the x-ray beam that passes through the centre of the bone traverses the maximum diameter of the plate and therefore more radiopaque material.

The lines seen at the injured physis are thicker than those at other locations in the same patient, and early growth stimulation is also evidenced by the reversal of the difference in growth rates at the distal and proximal physes. It has been suggested that such stimulation decreases after the first year (Reynolds 1981: Ogden 1982).

We have presented the natural history of growth disturbance lines and the pattern of displacement of the physes after distal tibial physeal fractures. We suggest that future function of the physis may be predicted from the appearance of the growth disturbance line as early as three months after injury, and used to assess the need for surgery before there is any gross deformity. Growth disturbance lines can easily be seen on standard radiographs and, at the distal tibial physis, are reliable indicators of growth plate activity after fracture.

The authors wish to thank Mr George Scully, Medical Photographer for the illustrations and Ms Sandra Black, Orthopaedic Secretary, for the preparation of the manuscript.

**REFERENCES**


