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FRACTURES OF THE TIBIA IN CHILDREN

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A total of 102 children, aged 1–15 years, treated for fissures, infractions, and fractures of the tibia were studied to elucidate the influence of age, type of fracture, and mechanism of trauma upon the course of union. In addition, an assessment was made of the possibilities the child has of correcting deformities of the diaphysis during continued growth. Eighty-five of the children were followed up clinically and radiologically. The time taken for union to occur increased with increasing age. The "high energy" injuries were found to be more apt to cause transverse and comminuted fractures, with injury to the skin, than the "low energy" fractures. At the time of union, 25 patients had angular deformities. The mean correction of this deformity up to the time of follow-up was only 10 per cent. The tendency to correct the deformity ceased 18 months after the accident, and was independent of the child's age at the time of the accident.

Key words: tibia; fractures; children; conservative treatment; spontaneous correction of angular deformities

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During the period March 1971 to January 1972 a total of 102 children were admitted to the Gentofte Hospital for the treatment of fissures, infractions, or fractures of the tibia. The material does not include injuries involving either the proximal or distal tibial epiphysis. Figure 1 gives the age distribution and the sex ratio.

According to the radiographic appearances the fractures were divided into (1) fissures and infractions, (2) oblique fractures, and (3) transverse and comminuted fractures. Incomplete fracture lines were classified as fissures. Infractions are injuries with displacement, but without a breach of continuity in the entire circumference. In an oblique fracture the length of the fracture line is more than twice the width of the bone. In a transverse fracture the length of the fracture line is less than twice the width of the bone. Double fractures and other multi-fragmented fractures were classified as comminuted.

As stated by Adams (1964) the nature of the trauma is assumed to be reflected in the type of fracture, direct trauma being associated with transverse fractures and indirect trauma with oblique fractures. According to Bauer et al. (1962) the traumas can be divided into those caused by severe and those caused by moderate violence. The former com-

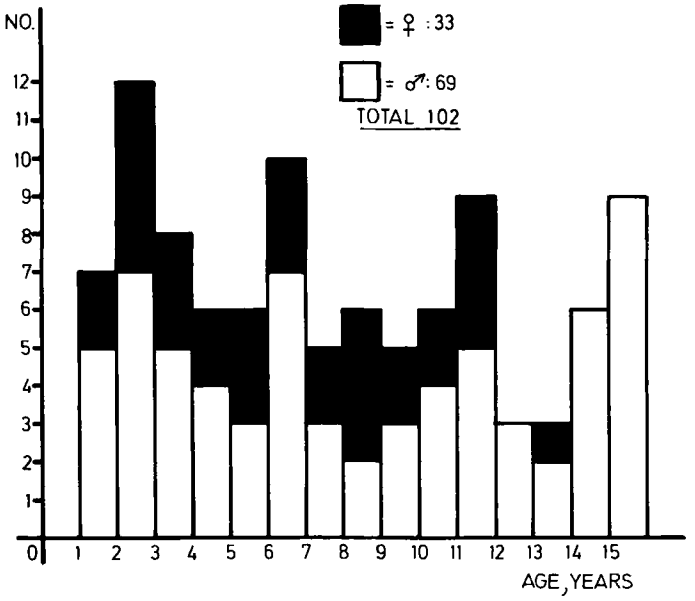

Figure 1. Age distribution and sex ratio. White columns represent number of boys within each age group; black columns the number of girls.

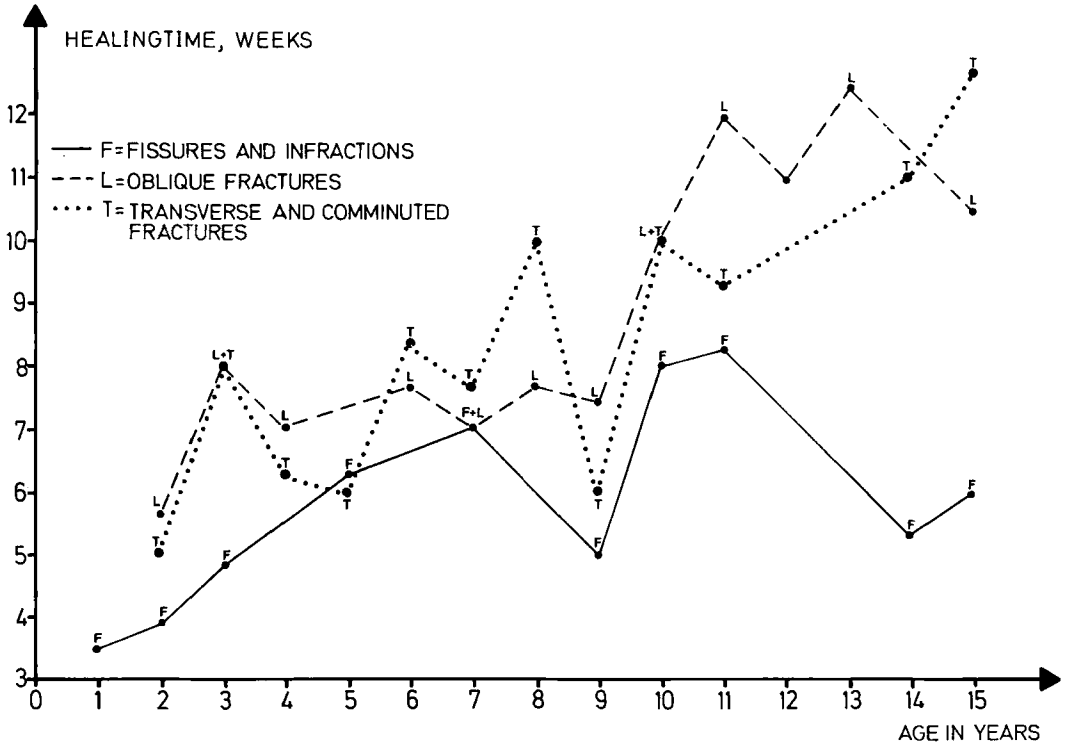

Figure 2. Mean times of union for each age group within the three types of fracture.

prise injuries in which a motor vehicle has been involved, or the patient has been hit by a heavy object, or has fallen from a height of more than 3 metres. Moderate violence is taken to mean a fall at ground level or from a low level (chair, bed, or the like), sport accidents, run into by bicycles etc. Table 1 lists the distribution of the fractures by type and mechanism of trauma.

TREATMENT

All the patients were treated conservatively in plaster casts, 62 without reduction, 33 after reduction, 4 after two or more reductions. Three fractures had initially been treated abroad and there was no information as to whether or not they had been reduced. One patient was briefly treated with calcaneal traction prior to the application of plaster.

Table 1. Distribution of the fractures according to type and mechanism of injury. The relation between fracture types and trauma is shown without distinguishing between boys and girls. Out of 33 patients exposed to severe violence, 22 sustained transverse or comminuted fractures, and 9 out of the 14 compound fractures were in this group. Out of 67 patients exposed to moderate violence, 49 sustained fissures, infractions, or oblique fractures.

TYPE / AETIOLOGY	FISSURES AND INFRACTIONS	OBLIQUE FRACTURES	TRANSVERSE AND COMMINUTED FRACTURES	TOTAL
SEVERE VIOLENCE	6	5 / 1	22 / 8	33 / 9
MODERATE VIOLENCE	26 / 1	23 / 2	18 / 2	67 / 5
NO INFORMATION	1	1		2
TOTAL	33 / 1	29 / 3	40 / 10	102 / 14

FRACTURES WITH AND WITHOUT SKIN INJURIES

FRACTURES WITH SKIN INJURIES

The time of union was assessed on the basis of clinical and radiological findings. In the present retrospective study the time of union was assumed to coincide with the time of removal of the plaster cast, which ranged from 2 to 18 weeks after the accident. The times of established union for each type of fracture, distributed according to age, are shown in Figure 2.

A stepwise multiple regression analysis was carried out on the times of union for each type of fracture. For fissures and infractions the union time in weeks was: age $\times$ 0.24 + 3.8 (with residual standard deviation = 1.7). For oblique fractures the time of union in weeks was: age $\times$ 0.48 + 4.8 (with residual standard deviation = 2.2). Lastly, for transverse and comminuted fractures in weeks: age $\times$ 0.51 + 4.8 (with residual standard deviation = 2.8). In other words, there is a very limited possibility of fixing the times of union on the basis of age and type of fracture.

Complications

The following complications were recorded: One patient had impaired sensibility in the foot, one had a peroneus palsy, one developed infection at the site of skeletal traction, and one developed a cutaneous necrosis on the heel. All these complications were transient and left no permanent damage.

FOLLOW-UP

Of the 102 patients, 85 (83 per cent), 56 boys and 29 girls, were followed up clinically and radiologically. All the follow-up examinations were performed by the authors. Seventeen patients were not included in the follow-up examinations, three because of deficient radiographic material, two because of continued treatment in other hospitals and two because of previous fractures of the same or the contralateral limb. The remaining ten patients failed to respond to the invitation to attend follow-up.

The distribution by fracture type in the follow-up material is shown in Table 2.

The follow-up period averaged 24.2 months, range 13–36 months.

Subjective assessment: In six cases the children and/or parents reported pain after major exertion; there was no cor-

Table 2. Distribution of fracture types in the follow-up material.

Types of fracture	No. of pts.
Fissures and infractions	28
Oblique fractures	24
Transverse and comminuted fractures	33
Total	85

relation between the subjective assessment and the clinical/radiological findings.

Objective assessment: There were no patients with a limp or abnormal toe-off in walking. In all cases there was a symmetrical movement in the hip, knee, and ankle joints. In two instances there was restriction of subtalar mobility of one-third and two-thirds that in the contralateral subtalar joint.

Rotational deformity was assessed only clinically. This was found in five patients and was between 10° and 20°.

At the radiographic examination, spot orthoradiography was done on all 85 patients.

The material was analysed with a view to spontaneous correction of angular deformities at the fracture site during the period between union and follow-up. In measuring the angular deformity we measured the angle between the axes of the diaphyseal fragments proximally and distally to the fracture site without regard to apposition and resorption at this level. The degrees stated are the sum of the angulation in the anteroposterior and lateral views. The measurements are illustrated in Figure 3 b.

At the completion of treatment 25 patients had angular deformities between 4° and 19°. The same 25 patients still had major or minor angular deformity at follow-up, range 3°–19°. At the time of union the angular deformity among the 25 patients was found to total 252°, at follow-up 218°. Thus, the spontaneous correction had been 252–217 = 34°, viz.

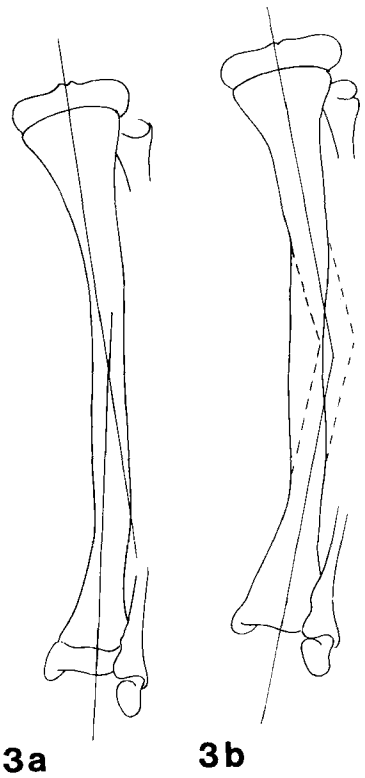

Figure 3. Measurement of angular deformity. (a) Angular deformity measured as the angle of intersection between a line placed through the centre of the bone ends and the centre of the diaphysis. (b) Angular deformity measured as the angle of intersection between the prolonged axes of the proximal and distal fragments (method used in the present study).

a correction of 13.5 per cent. Figure 4 gives the correction for the individual age groups; Figure 5 that in relation to the length of follow-up period.

The correction during the follow-up period was not correlated with the angular deformity at the time of union.

DISCUSSION

Treatment of fractures of the lower leg in children is considered to be gratifying, as they have, as stated by Blount (1955), a short time of healing, a low complication rate, and no cases of delayed union or non-union, if surgery is omitted.

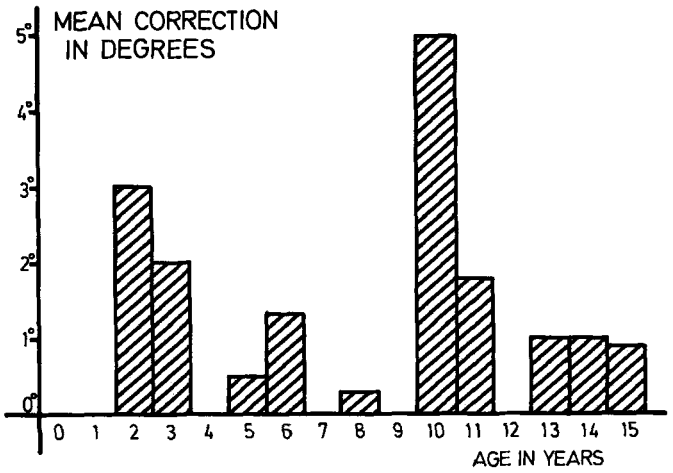

Figure 4. Correction of angular deformity in the individual age groups. On the ordinate, the mean correction in degrees, on the abscissa, age. A Spearman rank test ($R_s = -0.08$, $N = 25$) showed no significant correlation between correction and age ($P > 0.5$).

In the present material there were no cases of delayed union or non-union in the 99 patients whose treatment was completed in our department. Complications were transient. At follow-up six patients reported pain after major exertion.

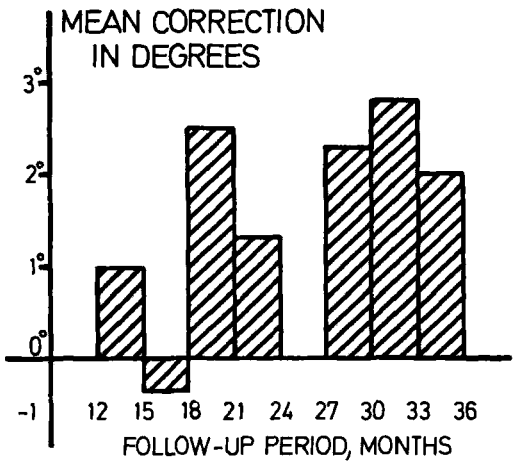

Figure 5. Influence of follow-up period on correction of angular deformity. Ordinate: Mean correction of angular deformity in degrees. Abscissa: Follow-up period in months. A Spearman rank test ($R_s = 0.45$, $N = 25$) showed a significant correlation ($P < 0.01$) between correction and follow-up period.

In two of these cases this could possibly be explained by the severity of anisomelia and angular deformity present.

At the clinical examination it was difficult to assess the rotational deformity. A deformity of between 10° and 20° was recorded in five patients, but in two of these the injury was merely a fissure, so that the measurement must be assumed to be incorrect. It is unsatisfactory not to have a practically applicable method for assessing rotational deformity. In particular, it would be of interest to check this displacement after the primary reduction, as it is generally considered the only deformity which children do not spontaneously correct (Blount 1955).

From the literature Edwards (1965) collected large series of lower leg fractures in adults. Out of 1558 conservatively treated cases of closed fractures three, or 0.2 per cent, developed osteomyelitis. Out of 723 cases of compound fractures he found 107 cases (15 per cent) of osteomyelitis. Moreover, he found the time of union for compound, transverse fractures to be up to four times that of closed oblique fractures. In our material primary union occurred in all 99 children.

Fourteen compound fractures, 10 of which were in the group 'trauma resulting from severe violence', posed no special problems, the union time within this group being within that expected for the corresponding age groups with closed fractures.

As may be seen from Figure 2, the times of union for fissures and infractions within the individual age groups are somewhat shorter than those for oblique and transverse fractures. In contrast, there is no difference in the times of union for transverse and comminuted fractures on the one hand and oblique fractures on the other. As demonstrated by the regression analysis, the time of union increases with increasing age for all types of fracture.

In 25 patients the examination on completion of treatment showed angular deformity. At follow-up there was still marked angular deformity, viz. 86.5 per cent of that measured at the time of union. The mean deformity at the time of union was about 10° for each age group. The correction proved to be independent of the extent of deformity at the time of union. From Figure 4 it is apparent that, unlike Swann & Oppers (1971) and Moesner et al. (1966), we did not find decreasing correction of the angular deformity with increasing age.

As shown in Figure 5, we observed some correlation between correction of angular deformity and follow-up period in all 25 patients with deformity (Spearman rank test $R_S = 0.45$; $N = 25$; $P < 0.01$). However, analysis of the 16 patients followed for more than 18 months (Spearman rank test $R_S = 0.22$, $N = 16$) no longer showed a correlation between correction and follow-up period ($P > 0.1$).

The difference between the findings of previous authors and the findings in this study is presumably due to the measuring method outlined in Figure 3, which does not take into consideration apposition or resorption at the fracture site. This apposition and resorption must be assumed to influence the static condition at the fracture level, but remodelling at the fracture site alone does not alter the static condition in the knee joint and ankle joint. Thus, if the deformity is not corrected in the epiphyseal plates, the weightbearing on the adjacent joints will remain faulty.

In conclusion, prognosis of plaster-treated fissures, infractions, and fractures of the tibia is favourable in children up to fifteen years of age. Primary union may be expected in all cases regardless of the type of fracture, whether the fracture is compound or closed, and whether the mechanism of the injury is a high or low energy force. Complications are few and transient.

A correct axial reduction has to be performed, as a correction of the angular deformity of more than about 10 per cent of the original deformity cannot be expected, irrespective of the child's age at the time of fracture.

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