

Epidemiology of knee injuries in children

We analyzed 91 consecutive metaphyseal fractures, physeal injuries, and ligament ruptures in children aged 0-14 years. In the younger children, metaphyseal fractures dominated, whereas teenager had ligament rupture associated with low-energy trauma and physeal injury with high-energy trauma.

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There are differences between children and adults regarding frequency, incidence, and types of lesions about the knee, as has been documented rather randomly by reports treating single types of lesions. However, the mutual relations of these lesions have not been analyzed. We report the age-specific incidence of the different types of knee lesions in children from a well-defined population during a 12-year period.

Patients and methods

Ligament ruptures, metaphyseal fractures, and physeal injuries of the distal femur and the proximal tibia in children aged 0-14 years, treated at the Departments of Orthopedics at Sønderborg, Esbjerg, and Frederiksberg Hospitals in Denmark, 1970-81, were included. Fractures of the patella, minor avulsions of the tibial tuberosity, pathologic fractures, and nonresidents were excluded. Sex, side, age at the accident, the type of lesion and trauma, and concomitant injuries were culled out from records and radiographs.

The number of children aged 0-14 years resident in the areas served by the hospitals fell from 59,088 in 1970 to 48,197 in 1981. The total population was fairly stable: about 250,000.

The study included all the fractures situated either in the proximal quarter of the tibia or the distal quarter of the femur. Buckle fractures were identified as nondisplaced compression fractures, whereas greenstick fractures were fractures with intact periosteum on one side and a small gap of cortex on the opposite side. Physeal injuries were classified according to Salter & Harris (1963). Ligament injuries

were included only if demonstrated operatively or as an avulsion fracture or on stress radiographs. Fractures of the tibial spine were classified according to Meyers & McKeever (1959).

All traffic accident in which a motor vehicle had been involved and falls from a height more than 3-4 meters were considered high-energy trauma. All the other accidents were classified as low-energy trauma.

For statistical calculations the Mann-Whitney and the chi-square tests were used.

Results

There were 91 injuries in 89 children (Table 1, Figure 1); 43 lesions were on the right side and 48 on the left side in 47 boys and 42 girls. Thirty-nine injuries were caused by high-energy trauma and 52 by low-energy trauma. All the injuries were closed. One child had a simultaneous injury of the tibial physis and the cruciate ligaments. Ten children had other serious injuries, either major fractures or cerebral concussions.

The metaphyseal fractures of the femur and tibia, respectively, constituted approximately 10 per cent of all the femoral or tibial fractures in the children occurring during the period.

The metaphyseal fractures were the predominant lesion among the younger children with a median age of 5 years (Table 2). Children with buckle fractures were younger than children with other fractures ($P < 0.001$). Buckle fractures and complete fractures were more common in the femur, whereas green-

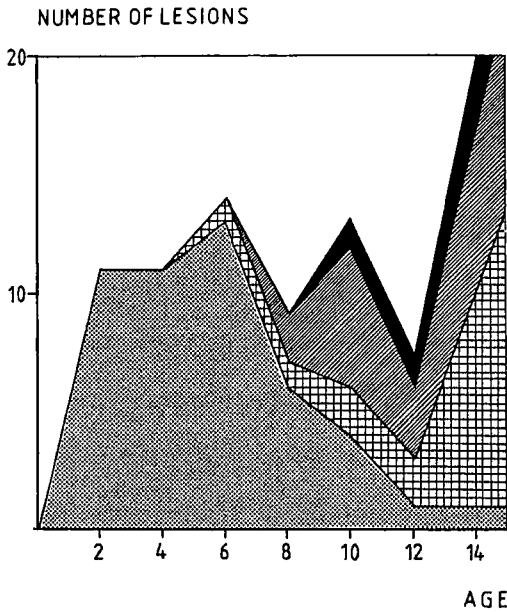


Figure 1. The age distribution of metaphyseal fractures , physal fractures , tibial spine fractures , and ruptures of collateral ligaments .

stick fractures and fissures were more common in the tibia. Out of 23 metaphyseal fractures caused by high-energy trauma, 18 were either complete or greenstick fractures. Out of 28 metaphyseal fractures caused by low-energy trauma, 19 were either fissures or buckle fractures ($P < 0.001$).

Children with physal fractures (Table 3) had a median age of 12 years. Eleven fractures were caused by high-energy trauma and four

Table 1. Knee injuries in children

Type of lesion	N	Annual incidence per 100.000
Distal metaphyseal fracture of the femur	13	2.0
Fracture of the distal femoral physis	7	1.0
Rupture of the collateral ligaments	5	0.7
Fracture of the tibial spine	20	3.0
Fractures of the proximal tibial physis	8	1.2
Proximal metaphyseal fracture of the tibia	38	5.6
Total	91	13

Table 2. Metaphyseal knee fractures in children

	Number of fractures		Median age years
	Femur	Tibia	
Fissures	1	12	4
Buckle fractures	7	4	2
Greenstick fractures	0	15	7
Complete fractures	5	7	7
Total	13	38	

by low-energy trauma. The fracture lines in the tibial Type IV injury engaged the tibial spine with avulsion fractures of both cruciate ligaments (Figure 2).

Children with ligament injuries had a median age of 12 years; no lesions of the cruciate ligaments without bony avulsion were diagnosed. There were 18 fractures of the tibial spine indicating avulsion fracture of the tibial insertion of the anterior cruciate ligament. Five were Type I, nine Type II, and four Type III fractures. (Meyers & McKeever 1959). Two fractures of the tibial spine indicated rupture



Figure 2. Salter-Harris Type IV physal fracture of the proximal tibia with avulsion fracture of the insertions of the cruciate ligaments (arrow).

Table 3. Number of physeal injuries according to Salter & Harris

	I	II	III	IV
Femur	1	5	0	1
Tibia	3	2	2	1
Total	4	7	2	2

of the posterior cruciate ligament (Figure 3). The most frequent cause of these injuries was falls. There were 4 patients with injuries of the medial and 1 of with an injury of the lateral collateral ligaments. Three injuries were verified by operation, one as a bony avulsion and one was diagnosed by a stress radiograph.

Only six of a total of 25 ligament ruptures were caused by high-energy trauma. High-energy trauma more often caused physeal injury, whereas low-energy trauma was associated with ligament rupture ($P < 0.001$). Serious concomitant lesions were accordingly almost exclusively seen in combination with either metaphyseal or physeal fractures; most of these high-energy injuries were due to traffic accidents. Both types of trauma were amply represented in all age groups, apart from the very young children, who did not sustain a high-energy injury.

Discussion

Our results are, with few exceptions, consistent with what has been found by previous investigators (Stephen & Louis 1974, Lombardo & Harvey 1977, Burkhart & Peterson 1979, Shelton & Canale 1979, Hertel 1981, Molander et al. 1981, van Laer et al. 1982, Skak 1982, Grönkvist et al. 1984). Landin (1983) found the same incidence of fractures of the tibial spine.

Peterson & Peterson (1972) and Shelton & Canale (1979) found that injuries to the distal femoral physis were more common than to the proximal tibial physis. According to Weber et al. (1980) and Rang (1982), this is due to the different insertions of the collateral ligaments in relation to the physis and to the different shape of the epiphysis. However, in our study the lesions were equally frequent.

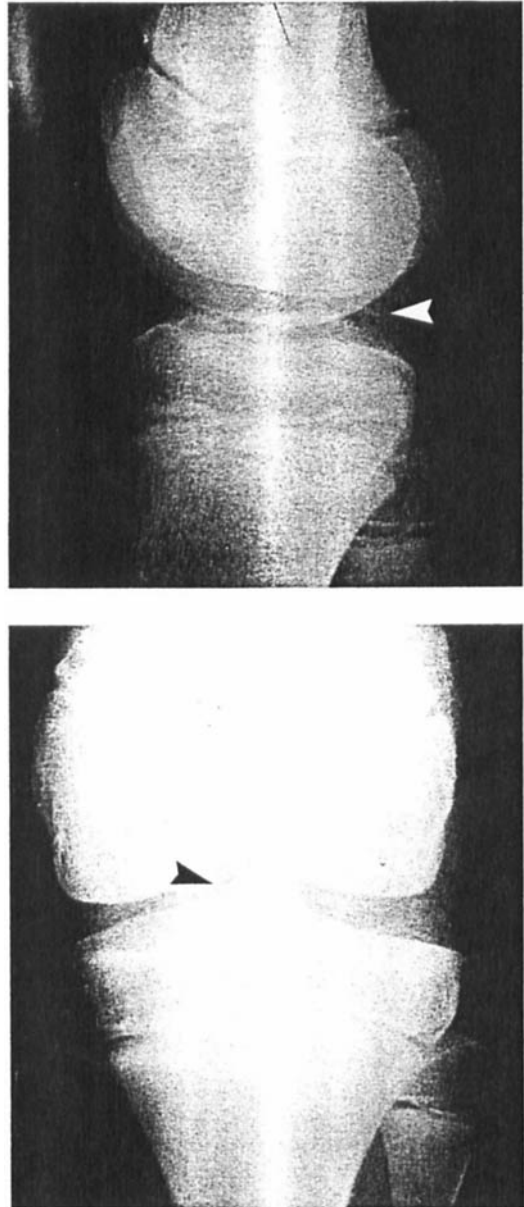


Figure 3. Fracture of the tibial spine indicating avulsion of the insertion of the posterior cruciate ligament.

The remarkable shift in the frequencies of different lesions taking place between the ages of 7 to 11 years (Figure 1) suggests a direct relation between low age and metaphyseal fracture: in young children the metaphysis seems to be relatively weak, with an increased risk of fractures of all types.

Kennedy (1979) drew attention to simulta-

neous occurrence of physeal and ligamentous injury, reporting a case of a concomitant Salter-Harris Type III lesion of the distal femur and avulsion fracture of the tibial insertion of the anterior cruciate ligament. Shelton & Canala (1979) and Gill et al. (1981) reported medial collateral ligament rupture associated with Salter-Harris Types II-III injury of the proximal tibial physis. Salter-Harris Type IV lesions of the proximal tibia are indeed very rare, but surprisingly associated avulsion fracture of the tibial spine has not been described, though the fracture line in these lesions may pass close to the ligament insertions.

The incidence of fractures in our study, including the incidence of bony avulsions of ligament insertions, is likely to be close to the true incidence in the population, whereas the incidence of tears through the ligament substance is underestimated. Such tears, particularly partial ones, are probably more common in children than generally assumed (Bradley et al. 1979, Clanton et al. 1979), but of minor significance because uneventful healing apparently is the rule.

Acknowledgements

This study was supported by grants from: Fonden for lægevidenskabelig forskning m.v. ved sygehusene i Ringkøbing, Ribe og Sønderjyllands amter. S. A. Skak's Familie Fond.

References

- Bradley, G. W., Shives, T. C. & Samuelson, K. M. (1979) Ligament injuries in the knees of children. *J. Bone Joint Surg.* **61-A**, 588-591.
- Burkhart, S. S. & Peterson, H. A. (1979) Fractures of the proximal tibial epiphysis. *J. Bone Joint Surg.* **61-A**, 996-1002.
- Clanton, T. O., DeLee, J. C., Sanders, B. & Neidre, A. (1979) Knee ligament injuries in children. *J. Bone Joint Surg.* **61-A**, 1195-1201.
- Gill, J. G., Chakrabarti, H. P. & Becker, S. J. (1983) Fractures of the proximal tibial epiphysis. *Injury*, **14**, 324-331.
- Grönkvist, H., Hirsch, G. & Johansson, L. (1984) Fracture of the anterior tibial spine in children. *J. Pediatr. Orthop.* **4**, 465-468.
- Hertel, P. (1981) Ergebnisse der operativen Behandlung von Eminentia-Ausrissen des Kniegelenkes im Kindesalter. Eine Analyse von 38 Fällen. *Unfallheilkunde* **84**, 397-404.
- Höllwarth, M. (1981) Frakturen der Eminentia intercondylica im Kindesalter. *Unfallheilkunde* **84**, 45-48.
- von Laer, L., Jani, L., Cuny, T. & Jenny, P. (1982) Die proximale Unterschenkelfraktur im Wachstumalter. Ursache und Prophylaxe des posttraumatischen Genu valgum *Unfallheilkunde* **85**, 215-225.
- Landin, L. A. (1983) Fracture patterns in children. Analysis of 8,682 fractures with special reference to incidence, etiology and secular changes in a Swedish urban population 1950-1979. *Acta Orthop. Scand. Suppl.* 202.
- Lombardo, S. J. & Harvey, J. P. Jr. (1977) Fractures of the distal femoral epiphysis. Factors influencing prognosis: a review of thirty-four cases. *J. Bone Joint Surg.* **59-A**, 742-751.
- Meyers, M. H. & McKeever, F. M. (1959) Fracture of the intercondylar eminence of the tibia. *J. Bone Joint Surg.* **41-A**, 209-222.
- Molander, M. L., Wallin, G. & Wikstad, I. (1981) Fracture of the intercondylar eminence of the tibia: a review of 35 patients. *J. Bone Joint Surg.* **63-B**, 89-91.
- Peterson, C. A. & Peterson, H. A. (1972) Analysis of the incidence of injuries to the epiphyseal growth plate. *J. Trauma* **12**, 275-281.
- Rang, M. (1982) *Childrens fractures*. J. B. Lippincott Co., Philadelphia and Toronto.
- Salter, R. B. & Harris W. R. (1963) Injuries involving the epiphyseal plate. *J. Bone Joint Surg.* **45-A**, 587-623.
- Shelton, W. R. & Canale, S. T. (1979) Fractures of the tibia through the proximal tibial epiphyseal cartilage. *J. Bone Joint Surg.* **61-A**, 167-173.
- Skak, S. V. (1982) Valgus deformity following proximal tibial metaphyseal fracture in children. *Acta Orthop. Scand.* **53**, 141-147.
- Stephens, D. C., Louis, E. & Louis, D. S. (1974) Traumatic separation of the distal femoral epiphyseal cartilage. *J. Bone Joint Surg.* **56-A**, 1383-1390.
- Weber, B. G., Brunner, C. & Freuler, F. (1980) *Treatment of fractures in children and adolescents*. Springer Verlag, Berlin, Heidelberg, New York.