

Growth disturbance after osteomyelitis of femoral condyles in infants

Growth disturbance after osteomyelitis in a single femoral condyle was seen in seven infants followed by the author from infancy to maturity. Age at onset of infection was between 10 days and 4 weeks. In three cases the medial condyle was affected and in four the lateral. Angular deformity of 20-50 degrees of varus or valgus was present before correction by supracondylar osteotomy. In all seven cases the radiographic appearance before the first osteotomy was similar. Partial closure of the growth plate appeared in four cases at age 6, 7, 10 and 12 years, respectively, which was decisive for loss of growth in length. These children had 3-6 osteotomies before maturity. In three cases partial closure of the plate did not occur, progression of angulation was slow and only two femoral osteotomies were carried out.

Restitution of the epiphysis and growth disturbance are unpredictable on the basis of radiographic findings during infancy. Partial closure of the growth plate may occur at the age of 4 years. Indications for correction of deformity and for epiphyseodesis in the other leg should be considered once or twice every year during the growth period.

Key words: epiphyses; femur; growth disorders; osteomyelitis.

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Although multiple bone involvement is common in acute osteomyelitis in the first weeks of life, the most common locations are the proximal and distal ends of the femur. When the distal end of this bone is the site of a focus of osteomyelitis this is mostly confined to one of the condyles. Lack of appearance or disappearance of a part of the epiphyseal nucleus and retarded metaphyseal growth of the condyle in question leading to varus or valgus deformity may occur as a sequel of destruction of epiphyseal cartilage and bone. Nowadays, the infection usually subsides under treatment with antibiotics, but during the first 2 years of life a typical angular deformity may appear which on the radiograph looks as though one of the condyles is lacking because it has remained cartilaginous.

The first case with the typical radiographic appearance mentioned above was reported by Banks et al. in 1940. Other authors have since reported similar cases (Hall 1954, Lloyd-Roberts 1960, Halbstein 1967, Miller 1969 and

Roberts 1970). The largest series was reported by Roberts (1970) who reported 11 cases with osteomyelitis in one femoral condyle and two cases in which both condyles were affected. Several of his cases were followed to maturity. Most of the authors who have reported cases of this type have found that significant recovery of the epiphysis and the growth plate may occur in some patients after a delay of several years. The radiographic findings are very similar in all cases when growth disturbance becomes apparent. However, Roberts (1970) stated that, "Radiographically, there appeared to be no way of telling which of the epiphyses would regenerate . . .".

The purpose of this report is to demonstrate the results in seven children in whom neonatal osteomyelitis of a femoral condyle caused growth disturbance followed by angular deformity and delayed appearance and growth of the corresponding part of the epiphyseal nucleus. All the patients were closely followed and treated by the author from infancy to

adulthood. The course of growth in these cases clearly indicates the importance of regularly repeated examinations and proper timing of operations in order to obtain the best possible result of treatment.

Case reports

The main data concerning the seven cases followed to maturity are given in Tables 1 and 2. Table 1 gives the data concerning onset of osteomyelitis and initial treatment, and Table 2 the data concerning treatment for growth disturbance and state after the growth period.

The acute stage

In all seven cases there was a fairly sudden onset with swelling around the affected knee at the age of 4 weeks or less. In cases 1, 5 and 7 penicillin therapy was started within 1 day after onset of symptoms, which possibly explains why the infecting organism was not identified in cases 1 and 5. In the other five cases *Staphylococcus aureus* was cultured from pus obtained by puncture of abscesses. In four of the cases there were multiple foci of infection. The medial condyle was affected in three cases and the lateral in four. In all cases radiographs taken of the affected knee in the acute stage showed changes typical for acute osteomyelitis, but these pictures were not later available.

Table 1. Data concerning onset of osteomyelitis and initial treatment

Case Initials	Sex	Date of birth	Age at onset of infection	Site of bony infection		Infecting organism	Initial treatment	Infection subsided
				Condyle of femur	Other bones			
1. A.S.	Female	Jan. 4 1951	10 days	Left med.	Left radius, right humerus, left dist. tibia	Not known	From day of onset penicillin. Within first week also streptomycin and aureomycin	Within 4 weeks
2. A.K.	Male	May 7 1954	3 weeks (possibly more)	Left lat.	None	<i>Staph. aureus</i> resistant to penicillin	From age 1 month streptomycin and chloramphenicol	Within 4 weeks
3. K.K.	Female	March 22 1955	3 weeks	Right lat.	None	<i>Staph. aureus</i> resistant to penicillin	From age 1 month penicillin for 6 days, then in addition streptomycin	Within 4 weeks
4. R.S.	Male	June 6 1955	2½ weeks	Left lat.	Left hip	<i>Staph. aureus</i> resistant to penicillin	Penicillin and streptomycin therapy started 1 week after onset, 10 days later erythromycin	Within 6 weeks
5. L.H.	Female	Aug. 16 1957	2½ weeks	Right med.	Right humerus	Not known	From day of onset penicillin. After flaring up in addition chloramphenicol	Within 3 weeks. Flaring up of osteomyelitis at age 4 mo
6. A.P.	Female	Jan. 15 1959	10 days	Left lat.	Right proximal tibia	<i>Staph. aureus</i> resistant to penicillin	From age 18 days penicillin for 5 days, then chloramphenicol for 10 days, then sigmamycin	Within 4 months
7. E.A.	Female	Aug. 6 1967	4 weeks	Right med.	None	<i>Staph. aureus</i> sensitive to penicillin	Penicillin therapy started 1 day after onset	Within 4 weeks

Table 2. Data concerning treatment for growth disturbance and state after the growth period

Case	Deformity before first osteotomy	Operations performed on the limbs			State of the limb at the time of the latest assessment					Course of growth (figures)
					Date age	Changes at the knee			Shortening (cm)	
						Angu- lar de- form- ity	Stabil- ity	Mov- e- ment (de- grees)		
1.	20 degrees varus at age 13 months	Femoral osteotomy Femoral osteotomy	Feb. 1952 Apr. 1957	May 1983 32 yrs	Slight varus	Slight laxity	10-110	9	Regeneration of medial condyle. No formation of epiphyseo-metaphyseal bone bridge. Figures 1 and 2	
2.	45 degrees valgus at age 3 yrs 7 mo	Femoral osteotomy Femoral osteotomy Femoral osteotomy Femoral osteotomy Epiphyseodesis r. fem. Femoral osteotomy	Dec. 1957 May 1961 Sept. 1962 Apr. 1964 Jan. 1966 May 1967 May 1969	Nov. 1978 24 yrs	None	Slight laxity	0-105	7	No growth of lateral part of metaphysis after partial closure of growth plate at age 6 yrs	
3.	30 degrees valgus at age 3 yrs 6 mo	Femoral osteotomy Femoral osteotomy Femoral osteotomy Femoral osteotomy	Oct. 1958 Oct. 1960 Jan. 1965 Aug. 1966 Jan. 1968	Nov. 1978 23 yrs	None	Un- stable	0-120	12.5	Partial closure of central part of growth plate at age 10 yrs causing "tenting deformity". Shortening 4.5 cm at age 9 yrs. Figure 3	
4.	25 degrees valgus at age 2 yrs 9 mo	Open reduction of left hip Femoral osteotomy Femoral osteotomy Femoral osteotomy Femoral osteotomy	Dec. 1957 Mar. 1958 Oct. 1962 Jan. 1965 Aug. 1967 Nov. 1969	Nov. 1978 23 yrs	None	Slight laxity	0-130	19	No growth of lateral part of metaphysis after partial closure of growth plate at age 7 yrs. No growth from capital growth plate after acute stage. Figure 4	
5.	30 degrees varus at age 3 yrs 3 mo	Femoral osteotomy Femoral osteotomy Epiphyseodesis left femur & tib. et fib. Femoral osteotomy	Nov. 1958 Sept. 1961 May 1969 Dec. 1970	Nov. 1978 21 yrs	None (Figure 8D)	Stable	0-140	3	Medial condyle regenerated. Partial closure of growth plate at age 12 yrs. Figures 5-8	
6.	50 degrees valgus at age 2 yrs	Femoral osteotomy Femoral osteotomy Right tibia required 5 osteotomies between 1961 and 1968	Feb. 1961 Jan. 1972	Dec. 1978 19 yrs	None	Stable	0-90	3	Regeneration of lateral condyle. No formation of epiphyseo-metaphyseal bone bridge. Figure 9	
7.	40 degrees varus at age 2 yrs 9 mo	Femoral osteotomy Femoral osteotomy Ostetomy of tibia for rotational deformity Epiphyseodesis of l. fem. 1979, tib. & fib. 1980	May 1970 Apr. 1974 Oct. 1975	Dec. 1982 15 yrs	None (Figure 12B)	Slight laxity	0-90	3	Grew from age 7 to age 15 yrs > 6 cm from injured growth plate with slight progression of varus. Epiphysis fair. Figures 10-12	



Figure 1. Case 1. AP radiographs.

- A) Age 8 months,
- B) Age 15 months, 6 weeks after first osteotomy,
- C) Age 3 yrs 5 mo, recurrence of varus,
- D) Age 6 yrs 2 mo before second osteotomy. Note radiolucent area in metaphysis (arrows).



Figure 2. Case 1. AP radiographs.

- A) Age 6 yrs 6 mo soon after second osteotomy.
- B) Tomograph, age 10 yrs 5 mo. Note radiolucent area in metaphysis (arrows),
- C) Age 17 yrs 5 mo. Note position of plate and screw indicating amount of growth after osteotomy (arrows in A and C).

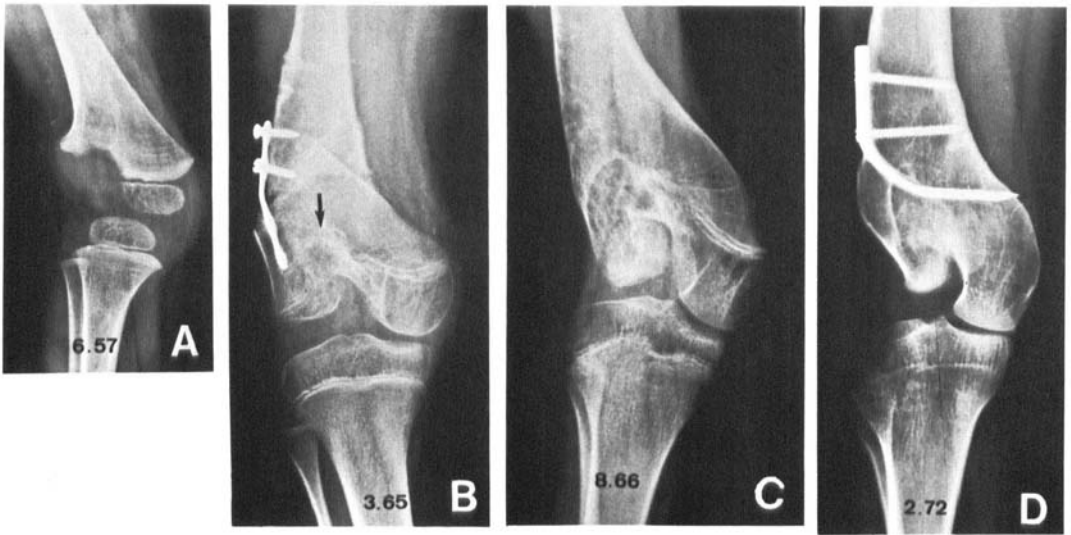


Figure 3. Case 3. AP radiographs.

- A) Age 2 yrs 2 mo. State 1 yr 4 mo before first osteotomy,
 B) Age 10 yrs. State 6 weeks after third osteotomy. Note partial closure of growth plate (arrow),
 C) Age 11 yrs 4 mo, "Tenting deformity". State before fourth osteotomy,
 D) Age 16 yrs 10 mo. State 4 yrs after fifth osteotomy.

In five cases (cases 1, 2, 3, 5 and 7), the signs of infection subsided within a month. Only in one of these cases was there a flaring up of the infection. All patients received treatment with antibiotics which was based on resistance patterns when the bacterium was cultured. In none of the cases could a sequester be seen in radiographs. Pus was obtained

by puncture in all cases and an abscess was opened in four cases (cases 1, 3, 5 and 7).

The growth disturbance

In five cases definite angular deformity at the affected knee was noted within the first year of age. In

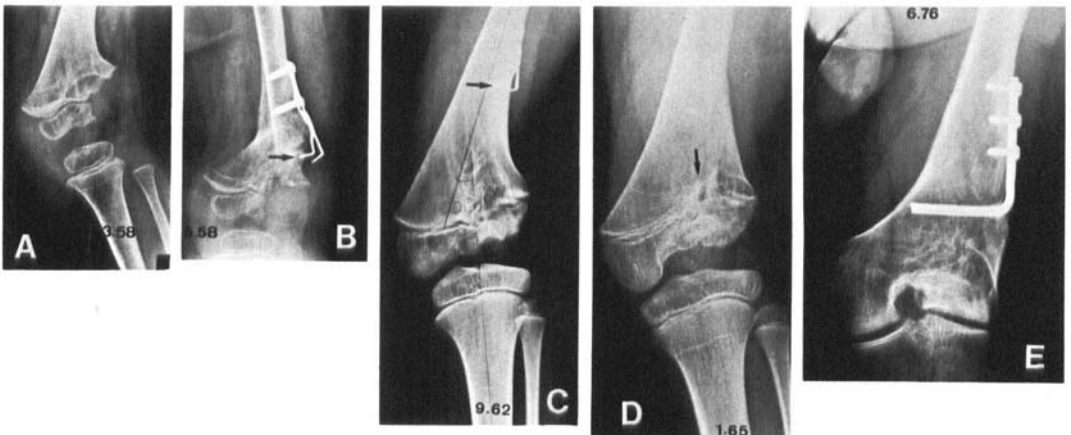


Figure 4. Case 4. AP radiographs.

- A) Age 2 yrs 9 mo. State before first osteotomy,
 B) Age 2 yrs 11 mo. State 6 weeks after first osteotomy.
 C) Age 7 yrs 3 mo. Recurrence of varus. Note position of metal plate and screws in B and C (arrow),
 D) Age 9 yrs 7 mo. State before third osteotomy, Note partial closure of growth plate (arrow),
 E) Age 21 yrs. State 6 yrs after fifth osteotomy.

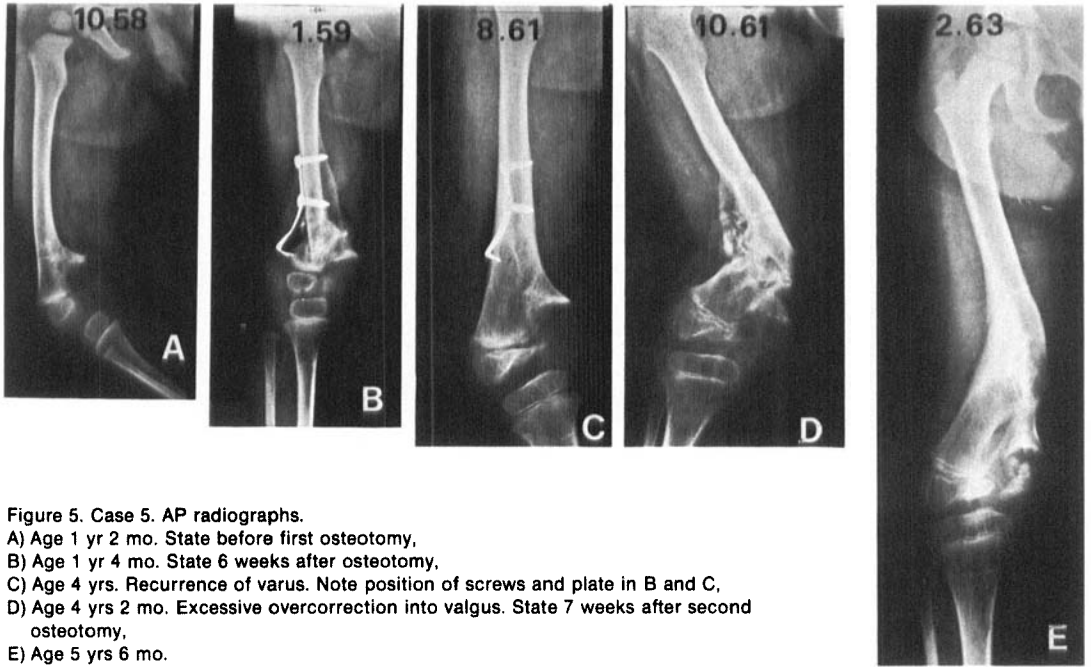


Figure 5. Case 5. AP radiographs.

- A) Age 1 yr 2 mo. State before first osteotomy,
- B) Age 1 yr 4 mo. State 6 weeks after osteotomy,
- C) Age 4 yrs. Recurrence of varus. Note position of screws and plate in B and C,
- D) Age 4 yrs 2 mo. Excessive overcorrection into valgus. State 7 weeks after second osteotomy,
- E) Age 5 yrs 6 mo.

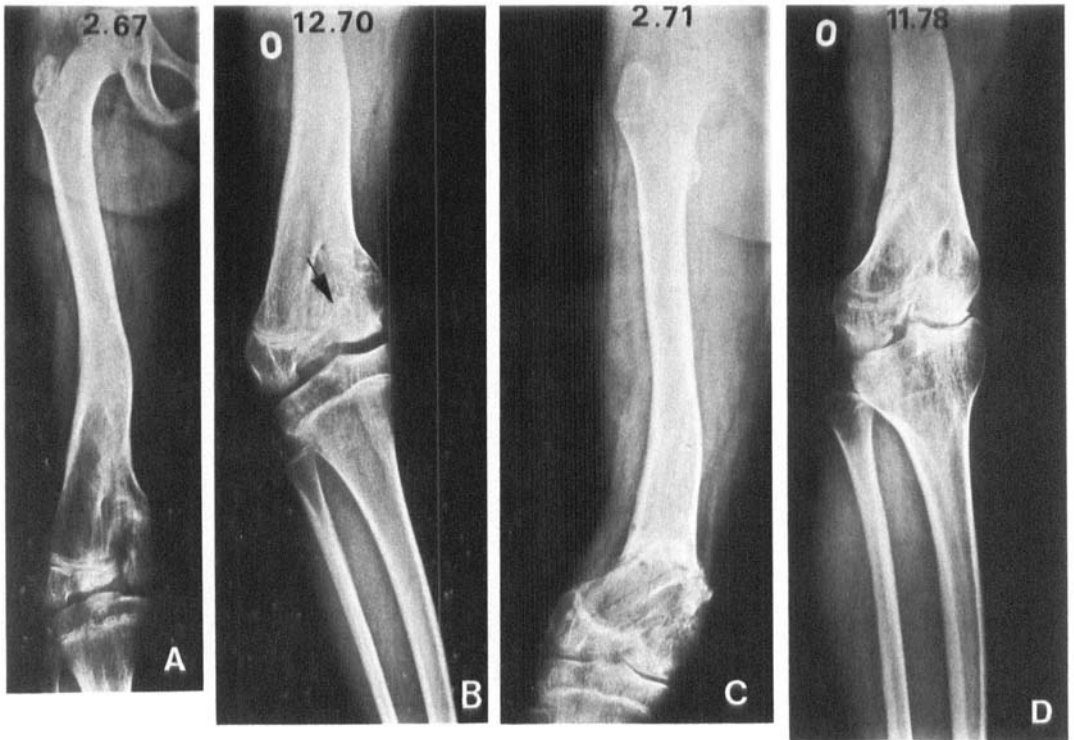


Figure 6. Case 5. AP radiographs.

- A) Age 9 yrs 6 mo. slight recurrence of varus,
- B) Age 13 yrs 4 mo. State before third osteotomy. Partial closure of growth plate (arrow),
- C) Age 13 yrs 7 mo. State 7 weeks after third osteotomy,
- D) Age 21 yrs.

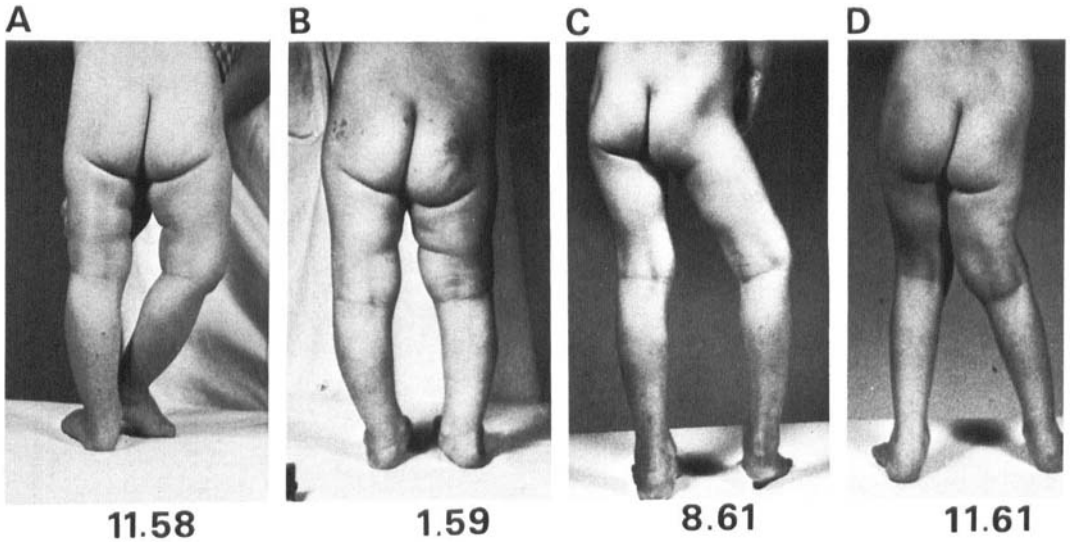


Figure 7. Case 5. Photographs.

- A) Age 1 yr 2 mo before first osteotomy,
 B) Age 1 yr 4 mo, 6 weeks after osteotomy,
 C) Age 4 yrs. Recurrence of varus,
 D) Age 4 yrs 3 mo. Overcorrection after second osteotomy.

one case (case 4) the history of gradually appearing deformity was given at age 2 years and in another (case 2) more than 3 years after the acute stage. In two cases the first osteotomy of the femur was per-

formed at the beginning of the second year and in three during the third year. In two cases the first osteotomy was performed during the fourth year of life.

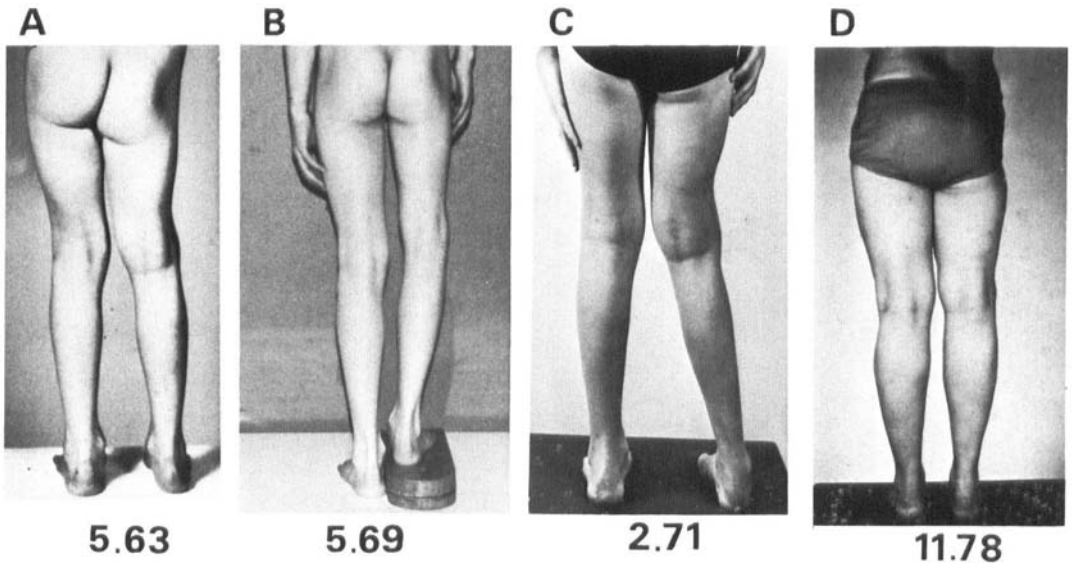


Figure 8. Case 5. Photographs.

- A) Age 5 yrs 9 mo. Valgus diminishing.
 B) Age 11 yrs 9 mo. Progressing varus 1 yr 7 mo before third osteotomy.
 C) Age 13 yrs 7 mo. Overcorrected into valgus. State 2 mo after third osteotomy,
 D) Age 21 yrs.

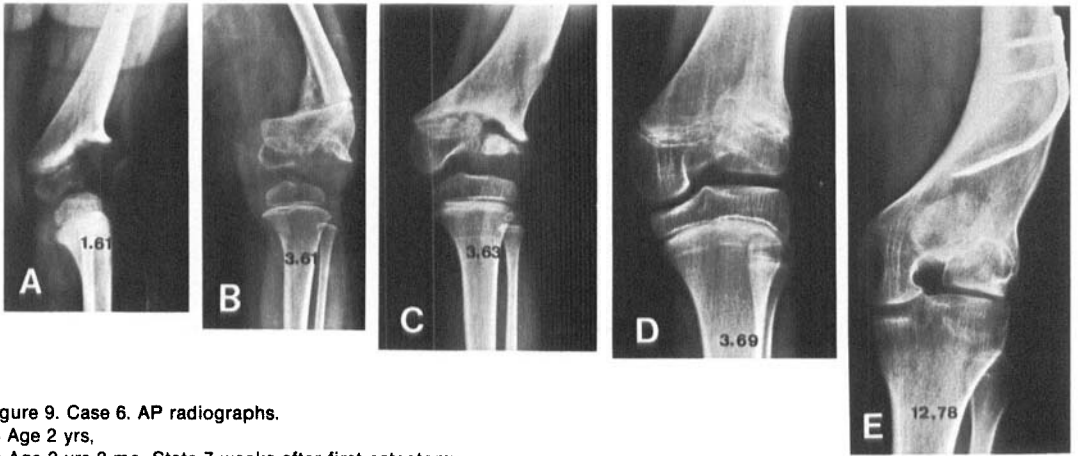


Figure 9. Case 6. AP radiographs.
 A) Age 2 yrs,
 B) Age 2 yrs 2 mo. State 7 weeks after first osteotomy,
 C) Age 4 yrs 1 mo,
 D) Age 10 yrs 1 mo, 2 yrs 10 mo before osteotomy,
 E) Age 19 yrs 11 mo. State almost 7 yrs after second osteotomy.

The degree of angulation before the first osteotomy varied between 20 and 50 degrees. The radiological changes at this stage were typical and very similar (Figures 1A, 3A, 4A, 5A, 9A and 10A). There was a definite defect in the metaphysis of the affected condyle and the corresponding part of the osseous epiphyseal nucleus was lacking. In all seven

cases femoral supracondylar osteotomy with overcorrection of deformity had to be repeated. In three cases two femoral osteotomies were sufficient; in one case three osteotomies were required; in two cases five osteotomies; and in one six osteotomies.

Usually 25 degrees of angular deformity was considered an indication for repeated correction and the

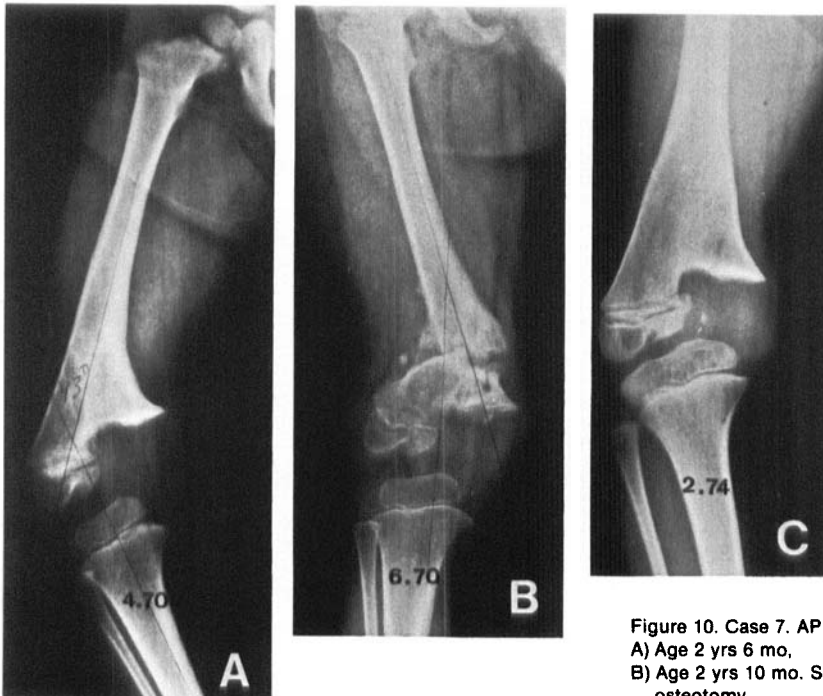


Figure 10. Case 7. AP radiographs.
 A) Age 2 yrs 6 mo,
 B) Age 2 yrs 10 mo. State 1 mo after first osteotomy,
 C) Age 6 yrs 6 mo. State 2 mo before second osteotomy. Recurring varus.

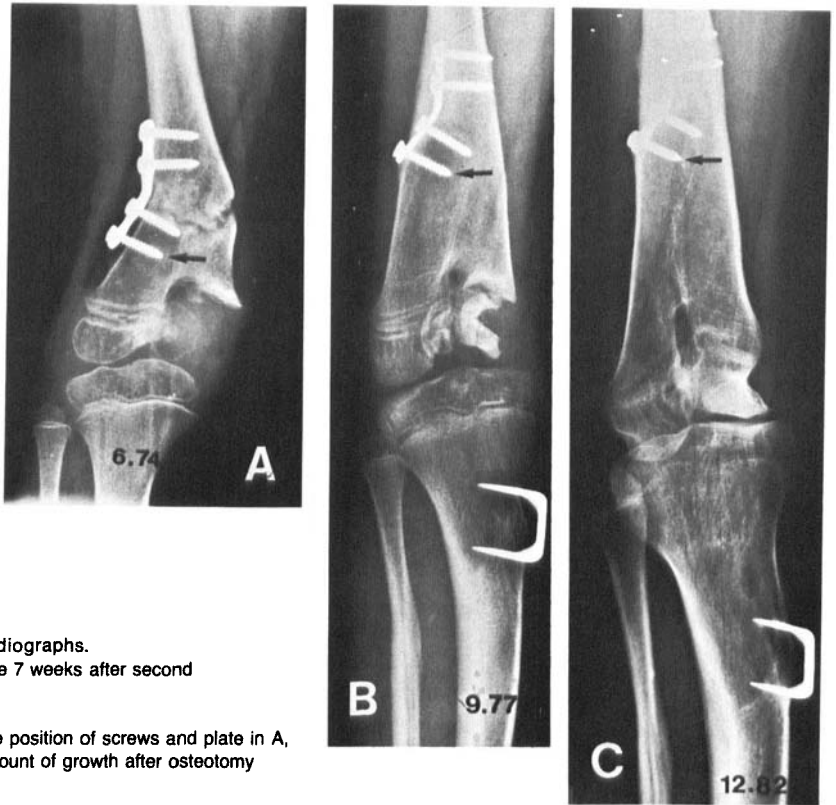


Figure 11. Case 7. AP radiographs.

- A) Age 6 yrs 10 mo. State 7 weeks after second osteotomy.
 B) Age 10 yrs 1 mo,
 C) Age 15 yrs 4 mo. Note position of screws and plate in A, B and C indicating amount of growth after osteotomy (arrows).

usual overcorrection was 20–30 degrees (Figures 5D, 7D, 8C, 9B, 10B and 11A). The technique of osteotomy used is evident from Figures 1–6 and 9–11. Some degree of locking of the fragments was usually attained by the cortex of the distal fragment being plugged into the marrow cavity of the proximal part of the bone. This technique also made it possible to bring the condyles into a suitable position in relation to the diaphysis. Internal fixation was not always necessary but usually some kind of plate combined with screws was used. A plaster was always applied for several weeks.

In two cases epiphyseodesis of the femur and the tibia and fibula on the non-affected leg limited the final leg length discrepancy to 3 cm (Cases 5 and 7). In one case growth disturbance of the tibia of the other leg also resulted in a limitation of shortening of the leg with the affected femur to 3 cm.

Comments on course of growth

Case 1. There was good regeneration of the epiphysis and the joint surface. Growth from the metaphysis of the affected condyle was considerable

(see position of plate and screw in Figure 2A–C). In the middle part of the metaphysis there was a layer of radiolucent tissue which apparently did not take part in the growth in length of the bone but neither did it form an impediment to growth as a bony bridge between epiphysis and metaphysis would do. The marked degree of shortening in case 1 was partly due to growth disturbance from a focus in the distal end of the tibia.

Case 2. Partial closure of a large peripheral segment of the growth plate appeared at age 6 years. This caused rapid recurrence of deformity after osteotomy, which had to be performed six times.

Case 3. Partial closure of the central part of the growth plate was evident at age 10 years (Figure 3B). After that, “tenting deformity” of the distal end of the femur and the joint surface and shortening progressed rapidly.

Case 4. Partial closure of a large peripheral segment of the growth plate appeared at age 7 years (Figure 4C and D). Rapid recurrence after osteotomy required five such operations before the end of the

growth period. Complete closure of the capital growth plate after the acute stage added to the discrepancy of leg length, which became extreme.

Case 5. (Figures 5–8) At the first osteotomy no overcorrection was produced and varus deformity soon recurred. The position of the plate and screws in Figures 5B and 5C shows that the metaphysis grew in length also in the region of the steplike defect. Extreme overcorrection at the second osteotomy postponed indications for a new correction for 10 years. At age 12 years partial closure of the growth plate occurred and caused accelerated progression of the deformity (Figure 6B). Epiphyseodesis of the femur and tibia and fibula on the other side was carried out. The epiphysis of the medial condyle regenerated gradually.

Case 6. Good regeneration of the epiphysis of the affected condyle and continued metaphyseal growth appeared. Only two osteotomies had to be performed. Growth disturbance from a focus in the proximal end of the tibia of the other leg compensated for discrepancy of leg length.

Case 7. Metaphyseal growth from the injured condyle was considerable, which can be seen from the position of the plate and screws in Figure 11A–C. The femur was osteotomized only twice but rotational deformity made an osteotomy of the tibia and fibula necessary. The regeneration of the epiphysis of the affected condyle was fair.

Results

Condition at last follow-up examination

The main data concerning the state at adult age are evident from Table 2. Although the radiological appearance of the affected femoral condyle at the age of 1–3 years before the first osteotomy was very similar in all cases, the final outcome at adult age varied very much. The regeneration of the epiphysis and the joint surface and the degree of growth of the metaphysis of the affected condyle were good or fair in cases 5, 6 and 7 (Figures 6D, 9E and 11C), resulting in fairly stable joints and a cosmetically acceptable appearance (Figures 8D and 12B). In cases 2 and 4, fairly good regeneration of the epiphysis resulted in joints with only slight laxity, but partial closure of the growth plate caused shortening, which was extreme in case 4. Case 3 was the only one in

which severe instability was present at adult age. "Tenting deformity" and poor development of the lateral condyle caused laxity into valgus position (Figure 3D).

At the last follow-up examination none of the patients felt any pain in the affected knee. The three patients who had only 3 cm of shortening walked without a limp with 1–2 cm elevation of the heel. One patient used an orthopaedic shoe (Case 4) and one (Case 3) walked with the foot in equinus, avoiding elevation of shoes.

Discussion

The pathology of osteomyelitis in infants was elucidated by Ogden in 1979. He concluded that the amount of growth disturbance after osteomyelitis in infancy is directly related to the destruction of the growth plate and portions of the epiphysis by the infectious process. The location of the area of cartilage destruction is probably decisive for the degree of regeneration of the epiphysis and the joint surface on one hand and for the amount of growth in length of the bone from the affected part of the growth plate on the other hand. In case 2, regeneration of the epiphysis was fairly good but growth in length of the bone was severely affected. In case 7 regeneration of the epiphysis was not complete but growth in length from the injured part of the plate was considerable.

About the sequels of neonatal osteomyelitis in the knee region, Roberts (1970) wrote: "In the early stages the radiographic appearances may be deceptive, suggesting that damage to the epiphysis is irreparable." The possibilities for considerable regeneration of the epiphysis and the growth plate in this kind of case have been pointed out by several authors (Hall 1954, Siffert 1957, Bachmann & Bossuyt 1960, Lloyd-Roberts 1960, Hübner 1964, Halbstein 1967 and Miller 1969).

Even when partial closure of the growth plate does not occur and other parts of the limb in question are unaffected, as in case 7, a certain delay of longitudinal growth occurs in the distal end of the femur causing discrepancy of leg length. The 11 patients in Roberts' (1970)

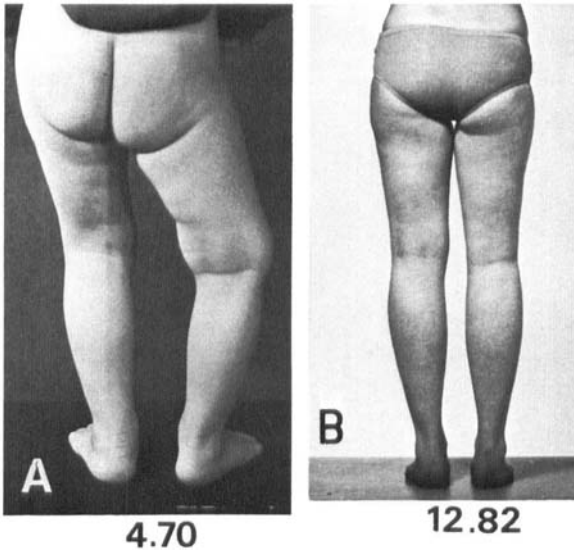


Figure 12. Case 7. Photographs.

A) Age 2 yrs 6 mo before first osteotomy,
 B) Age 15 yrs 4 mo.

series all had shortening varying from 5.0 to 12.5 cm.

Partial closure of a large peripheral segment of a growth plate as seen in cases 2 and 4 is not a favorable subject for bone bridge resection. This has earlier been pointed out by the author (Langenskiöld 1981a). When these patients were treated, the method for resecting bone bridges had not then been developed but even today such an operation would not be recom-

mended for in such a case. In case 3 partial closure of the central part of the plate at the age of 10 years caused rapidly progressing deformity and shortening. A planned epiphyseodesis of the other leg was discarded because excessive shortening could be expected. If resection of this central bone bridge had been performed when the girl was 10 years old in 1965 and epiphyseodesis had been carried out in the other leg, the amount of final shortening could possibly have been 3 cm instead of 12.5 cm. Resection of central bone bridges in the distal end of the femur has since been performed with good results and has prevented progression of "tenting deformity" (Langenskiöld 1981a, 1981b). However, in 1965 only the first step in developing the method had been taken (Langenskiöld 1967).

The appearance of partial closure of the growth plate after osteomyelitis in infancy may occur at any age during the growth period and cannot be predicted. Follow-up examinations should be performed at least once every year. Figure 13 shows an example of how a central bone bridge had developed at the age of 4 years. A correcting osteotomy had been performed adequately at the age of 2½ years when the radiographic appearance was very similar to our cases.

Figures 14A–E show gradual regeneration of the distal femoral epiphysis after

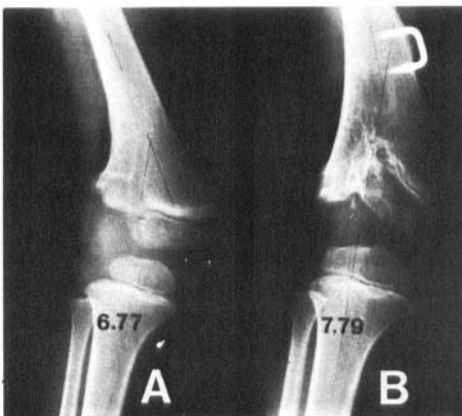


Figure 13. AP radiographs of special case.

A) Growth disturbance of lateral femoral condyle after osteomyelitis in infancy. Age 2 yrs.
 B) Same knee region at age 4 yrs. Partial closure of growth plate 2 yrs after osteotomy. Further treatment not known.

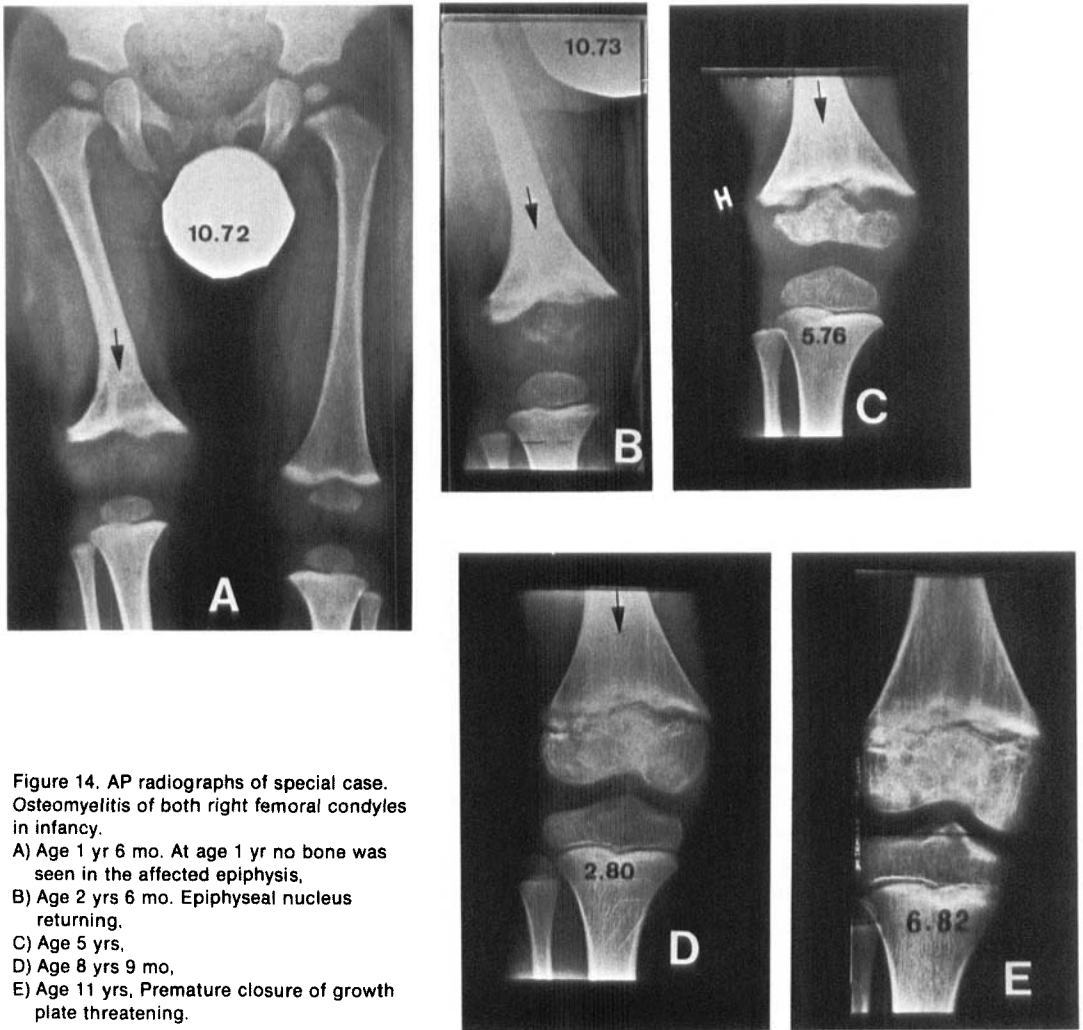


Figure 14. AP radiographs of special case. Osteomyelitis of both right femoral condyles in infancy.
 A) Age 1 yr 6 mo. At age 1 yr no bone was seen in the affected epiphysis,
 B) Age 2 yrs 6 mo. Epiphyseal nucleus returning.
 C) Age 5 yrs,
 D) Age 8 yrs 9 mo,
 E) Age 11 yrs, Premature closure of growth plate threatening.

osteomyelitis to a normal shape after the bony nucleus had been completely absent at the age of 1 year. On the other hand, metaphyseal growth was much impaired and at the age of 11 years there was 5.5 cm shortening. Complete premature closure of the growth plate could be expected and epiphyseodesis of the other femur was indicated.

In case 1 a phenomenon appeared which has earlier been described by the author (Langenskiöld 1955). In the central part of the bony epiphysis a plug-like extension developed which was separated from the metaphysis by an irregularly shaped layer of radiolucent tissue. It seems very probable that this layer was

non-growing fibrous scar tissue. Anyhow, this phenomenon does not mean a severe impediment to metaphyseal growth as bony bridges do. However, the sudden appearance of partial closure of a growth plate in some cases many years after the acute stage of osteomyelitis may be a result of ossification of fibrous scar tissue remaining in the zone of growth. The course of growth of the femur in case 1 shows that the phenomenon seen in Figure 2B is not an indication for operative measures in the region of the growth plate.

Conclusions

The main principles of treatment of the sequels of osteomyelitis of a single femoral condyle in infants can be determined from the course in the seven cases described above. These children have to be closely followed during the entire growth period. On the basis of clinical findings and serial radiographs, osteotomy with overcorrection of angular deformity has to be carried out when varus or valgus deformity has reached a degree markedly affecting function, which is about 25 degrees. Epiphyseodesis of the non-affected leg should be planned and performed at the most suitable time. Partial closure of the growth plate should be diagnosed before it has caused irreparable damage and, if feasible, treated by bone bridge resection. After the growth period, lengthening of the affected femur or shortening of the other leg may reduce the disabling effect of discrepancy of leg length. The regeneration of the epiphysis proper is difficult to influence by operative treatment. Thus the final shape of the joint surface is very much dependent on how the damage which occurred at the acute stage is spontaneously compensated.

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