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Early physeal closure after femoral chondrodiatasis

Loss of length gain in 5 cases

Chiaki Hamanishi¹, Seisuke Tanaka¹ and Kiyosi Tamura²

Chondrodiatasis (symmetric physeal distraction) was carried out in 5 patients with short femora because of congenital dislocations of the hip joint (4 patients) and congenital shortening (1 patient). In all but 1 case the physis closed shortly after lengthening, and loss

of gained length or further shortening ensued in all of them. Chondrodiatasis should be avoided in the subjects under 13 years of age with mild leg-length discrepancies.

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Ring (1958) first reported the experimental possibility of increasing the length of the femur by physeal distraction. Zaviyalov and Plaskin (1967) and Ilizarov and Soybelman (1969) first reported the clinical application of this technique. Experimentally, the growth plate could remain open after fracture separation and distraction in certain conditions in some animals, such as puppies (Ring 1958, Fjeld and Steen 1990) and lambs (Monticelli and Spinelli 1981, De Pablos et al. 1986, Steen and Fjeld 1987, Fjeld and Steen 1988, 1990). Clinically, because of the possibility of the interruption of further growth, Monticelli and Spinelli (1981) had advocated this method of distraction physiolysis (0.25 mm, four times daily) for patients older than 13 years of age. De Bastiani et al. (1984), however, reported that lengthening could be gained without resultant physeal closure if distraction was performed more slowly (0.25 mm twice daily), and they called this new concept chondrodiatasis. They reported cases of patients even younger than 10 years of age, as well as histologic evidence of thickening of the hypertrophied zone of the growth plate in rabbits. Although the hyperplasia of the growth plate in rabbits was also reported by Spriggins et al. (1989) and Kenwright et al. (1990), only a small increase in limb length was detectable. The results after distraction physiolysis in patients younger than 13 years of age were reported recently (Bjerkreim 1989), but the long-term results after chondrodiatasis of patients operated on at a young age have not been reported.

We carried out chondrodiatasis in five femora in 1985, and the long-term results are reported here.

Patients and methods

Unilateral chondrodiatasis was performed in 5 patients, aged 11–13 years. The etiology of the shortening was deformities of the femoral head due to congenital dislocation of the hip joint (CDH) in 4 cases and congenital Type 1 short femur in 1 case (Table 1). The dysplastic acetabuli had previously been corrected with Salter's innominate osteotomy (Case 1) and shelf plasty (Case 5). The shortening of the femora was 24 (10–33) mm, and the length was 94 (91–98) percent of that of the contralateral normal side. In Case 4 the femoral shortening was only 1 cm, but the tibia was also 1-cm short.

Lengthening procedure

Two cancellous screws of Dynamic Axial Fixator (Orthofix) were inserted in parallel into the distal femoral epiphysis from the lateral side. They were fixed by the DAF lengthener with two cortical screws inserted into the diaphysis. Lengthening was started on the next day: viz., 0.25 mm every 12 hours. Partial weight bearing was allowed 3 days postoperatively. Radiographs of the knee were obtained in a supine position twice weekly until widening of the physis became manifest, and then once a week until lengthening was concluded. The entire length of both the normal and the lengthened femur were measured from the top of the femoral head to the intercondylar notch using scanograms with scales; the measurements were made every other week during lengthening, once during neutralization, before and after dynamization,

Table 1. Particular details of 5 cases in which unilateral chondrodiatasis was performed

	Sex	Etiology	Preoperatively			Lengthening		Postoperatively	Last follow-up		
			Age	Discrepancy (mm)	Length ^a	Period (day)	mm		Length ^a	Age	Discrepancy Length ^a
1	F	CDH	11	33	91	89	43 ^b	101	12	50	88
2	M	Congenital	11	21 ^c	95	65	29	100	15	40 ^d	92
3	F	CDH	12	24	94	63	25	98	16	23	95
4	F	CDH	12	10 ^c	97	72	30	103	15	10 ^d	98
5	M	CDH	13	31	93	60	32	100	14	10	98

^aRelative length of the shorter femur to the contralateral normal femur in percentages.

^bCollapse of the callus of 30 mm occurred afterwards.

^cTibia was also 10 mm shorter.

^dTibia was also 12 mm shorter.

and every 4 months during the follow-up period. Three patients complained of knee pain 7 to 10 days after initiating the lengthening, when radiographs first indicated the widening of the growth plate. Sound callus formation was observed, and the lengtheners could be removed after 4 to 6 weeks of neutralization and 2 weeks of dynamization. The follow-up period was 32 (18–45) months.

Results

The femora were lengthened 32 (25–43) mm after 70 (60–89) days of distraction to 100 (98–103) percent of that of the normal side (Figure 1). The physes were closed shortly after lengthening in the 4 CDH cases (Figure 2) and remained partially open for 10 months

Figure 1. Change in the percentage of femoral length of the short femora compared with those of the normal side. Two arrowheads indicate collapse of the callus during neutralization in Case 1 and after removal of the lengthener in Case 5.



Figure 2. Case 4. Immediately before removal of the screws 4 months after starting chondrodiatasis. The physis has already been closed.

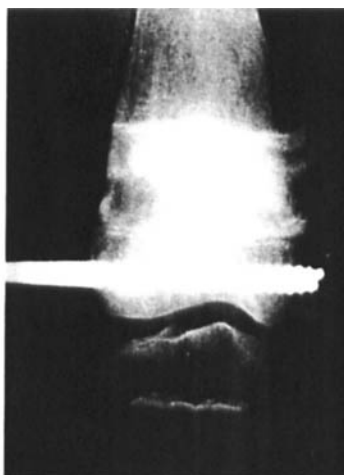


Figure 3. Case 2. Immediately before removal of the screws. The physis appears to have remained open.



Figure 4. Case 5. Marked asymmetric distraction occurred because of bending of the screws.

in Case 2 (Figure 3). At the last follow-up examination, the femora were again 27 (10–50) mm shorter and 94 (88–98) percent of those of the normal side. The additional growth of the short femora after completed distraction was 5 (0–10) mm in the 4 CDH cases and 35 mm in Case 2; and that of the contralateral, normal femora was 21 (7–30) mm in the 4 CDH cases and 75 mm in Case 2. The range of flexion of the knee joints was restricted to less than 40° during lengthening, but all of them returned to normal, mostly within 6 months. Discharge from the distal screws became uncontrollable in Case 1 during the neutralization period, and collapse of the callus of 30 mm occurred after removal of all the screws. Asymmetric distraction of the growth plate (wider on the lateral side) developed markedly in Case 5 (Figure 4) and moderately in Cases 1, 2, and 3, mainly due to bending of the screws. In Case 5, medial surgical release of the perichondrium and diaphyseal side of the growth plate was performed at 30 days of distraction. Mild collapse of the callus of 6 mm also occurred shortly after removal of the lengthener in Case 5. Two weeks of dynamization before removal of lengtheners did not cause any loss of gained length in Cases 2, 3, and 4.

Discussion

We chose rather young patients with mild discrepancies for chondrodiatasis because we believed that chondrodiatasis was the least invasive technique for children and because it had been reported that the growth plate continued to grow (De Bastiani et al. 1984). De Bastiani et al. (1986) reported on chondrodiatasis for 40 segments in 33 patients with leg-length discrepancies. They did not describe in detail the postoperative growth of the 10 segments in the patients operated on under 12 years of age, although the reduced rate of growth was suggested, especially in patients who were under 10 years of age. They did not restrict chondrodiatasis for any age group.

Recently, Kenwright et al. (1990) reported clinical evidence of proximal tibial epiphyseal separation at 12 days by a constant distraction of 0.5 mm per day, but data of further growth were not available. Bjerkreim (1989) reported 6 cases of distraction epiphysiolysis (1 mm/day) under 13 years of age, and subsequent growth of the lengthened tibia was 6 (0–20) mm compared with that of the normal side of 32 (12–58) mm. One of his 6 cases showed obvious, but retarded, growth from the distracted physis. These data were analogous to our experience: namely, that knee pain was complained of after 7 to 10 days of distraction, early closure occurred in 4 CDH femora, and gross

retardation ensued and strongly suggested that the 0.5-mm daily distraction (only 0.14 percent of the original length) caused physeal separation rather than the hyperplasia of the growth plate observed in the rabbits (De Bastiani et al. 1986, Spriggins 1989, Kenwright et al. 1990).

In larger experimental animals, such as dogs and lambs, growth plates appeared radiolucent after daily distraction of 0.5 mm or 0.25–1 percent of the original length, but a wide range of growth retardation up to 100 percent ensued (de Pablos 1986, Steen et al. 1987, Feljd and Steen 1988, 1990).

In our cases the additional growth observed in 4 CDH femora was probably taking place mostly at the partially damaged proximal femoral growth plates. In the case with congenital shortening where the physis seemed to be partially open for 10 months postoperatively, closure occurred eventually, and the discrepancy of leg length has later been increasing. In the congenital short femur, although the growth rate on the short side was potentially inhibited and relative length to the normal side did not change throughout the growth period (Hamanishi 1980), spontaneous premature closure never occurred.

In Case 5 only, operated on at nearly 13 years of age, the closure and subsequent growth disturbance were negligible. In the distal femoral physis, asymmetric distraction seemed to be unavoidable because of the bending of the long screws fixed by the unilateral lengthener. Other lengthener systems using transfixing pins (Ilizarov 1969, Bjerkreim 1989) could avoid or correct this deformity. Multisegmental massive lengthening for achondroplastic patients (Aldegheri et al. 1988) seemed to be the most acceptable indication for chondrodiatasis, and the rate of lengthening could be 1 mm per day or even more, because chondrodiatasis was nothing but distraction physiologically clinically.

Because the growth plate closed rapidly after the lengthening, we concluded that chondrodiatasis in the distal femur should be avoided in patients under 13 years of age with a mild leg-length discrepancy.

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