Complications of leg lengthening

46 procedures in 28 patients

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The results and complications of 46 leg-lengthening procedures in 28 consecutive patients were analyzed retrospectively. There were 24 femoral and 22 tibial lengthenings, performed for short stature (5 patients) and limb-length discrepancy (23 patients). Three methods were used: diaphyseal osteotomy, metaphyseal corticotomy, and distraction physiolysis. In the second group a satisfactory result was obtained more often and a lower complication rate was observed. The overall complication rate was high: 45 substantial problems occurred. We conclude that leg lengthening is difficult, requiring good preoperative examination and planning, and should be carried out only in specialized centers.

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We report the results of leg-lengthening procedures at our hospital, with emphasis on complications.

Patients and methods

During the period January 1980 through January 1988, 28 consecutive patients (16 females and 12 males) underwent 46 elongation procedures: 24 femoral and 22 tibial lengthenings (Table 1). The mean age at the start of the elongation was 12 (1–20) years for femoral and 15 (5–25) years for tibial lengthening. Indications for leg lengthening could be divided into two major groups: short stature (achondroplasia and bilateral physeal damage) in 5 patients and limb-length discrepancies in 23 patients. In the short stature group, 4 patients had had seven previous operations before elongation: four corrections of another deformity in the affected limb and three previous lengthening procedures. In the group with leg-length discrepancies, 18 patients had had 13 previous corrections and 13 previous elongations. More than one lengthening procedure was necessary in 9 patients; in this group 27 procedures were performed (Table 2).

Three methods of lengthening were used: diaphyseal osteotomy and distraction (Wagner 1971) in 11 patients, metaphyseal corticotomy and distraction (Monticelli 1983) in 7 patients, and distraction physiolysis (Monticelli 1983) in 4 patients. Six patients underwent different kinds of procedures. In metaphyseal corticotomy and distraction physiolysis, a modified circular fixator of our own special design was used: two transfixion Hoffman pins through the physis and three unilateral Hoffman pins through the diaphysis were connected with three horseshoe metal rings, connected with each other by three threaded bars.

Twenty-four femurs were lengthened: 17 by diaphyseal osteotomy and seven by metaphyseal corticotomy. The tibia was involved 22 times: seven by diaphyseal osteotomy, nine by metaphyseal corticotomy, and seven by distraction physiolysis. Fifteen femoral (two metaphyseal corticotomies and 13 diaphyseal osteotomies) and four tibial lengthenings (two metaphyseal corticotomies and two diaphyseal osteotomies) subsequently underwent osteosynthesis: 13 with an AO plate of special design, five with an interlocking intramedullary nail (Grosse-Kempf), and one with screws. The nail was inserted 2 weeks after removal of the lengthening device and application of skeletal traction. Simultaneous bone grafting was performed 10 times.

To assess the results of these procedures, data were collected regarding the acquired length in centimeters, and complications were recorded.

A lengthening procedure was considered satisfactory when equalization (i.e., discrepancy < 1 cm) was achieved without permanent disabling damage to joints, bone, nerves, or muscle power. In case of very large discrepancies (> 8 cm), reduction of 50 percent or more in one procedure without permanent disabling damage was considered successful. In case of short stature, an elongation of 7–9 cm per bone without permanent disabling damage was considered satisfactory.

Table 1. Methods and results

Case	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	M	16	f	r	7	4	4	1	58	4	21	0	1	79	1	1	1
2	M	19	f	r	5	13	8	1	91	8	65	1,2,5	1	69	2,3	1	2
3	F	11	f	l	1	9.5	5	1	69	20	56	1	1,2	59	2	1	1
3	F	13	t	l	1	4.5	5	3	58	41	58	2	3,3	35	1	1	1
4	F	20	f	r	1	6	4	1	40	7	27	1,2,3	1,3,3	42	2	1	2
5	F	5	f	l	1	12	5	1	87	36	79	1,2,3,6	1,3,3	54	2.3	2	2
6	F	6	f	r	11	3	4	2	53	20	53	1,3,6	3	12	1	1	1
7	F	19	t	r	6	–	8.5	2	64	56	56	1,2,4,5,	2,3	24	1	1	1
7	F	19	t	l	6	–	8.5	2	64	56	56	1,4,5	2,3	24	1	1	1
7	F	20	f	r	6	–	8	1	68	10	40	1,2,3	1,3	15	1	1	1
7	F	20	f	l	6	–	8	1	66	11	35	3	1	15	1	1	1
8	F	25	t	l	6	2	2	2	30	19	27	4	3	18	1	1	1
9	F	16	t	r	9	4	5	2	65	14	54	1,3	4	48	1	1	1
10	M	15	t	r	4	3	3.6	3	52	42	48	1,2,3	3,3	74	1	1	1
11	M	23	t	r	2	7	3	1	58	7	50	1,2	1,2,3,3	72	2	1	2
12	M	13	t	r	1	5	4.5	3	46	31	37	2,3	0	3	1	1	1
13	M	4	f	l	1	8.5	6	1	40	15	32	1,2	2,3,3	150	2	1	1
13	M	6	t	l	1	8	5	1	57	22	49	1,2,3	2,3,3,4	105	2	1	1
13	M	15	t	l	1	8.5	5	3	65	53	65	2,3	3	9	2.3	1	2
14	M	18	t	l	2	8	4	1	68	6	59	1,2	3,3,3	50	2	1	1
15	F	7	f	l	1	9	5.5	1	48	18	48	2,3,6	1,2,3	25	2	1	1
15	F	10	f	l	1	7	6.5	1	64	48	56	2,3,6	3,3	2	1	1	1
16	F	7	f	l	1	11.5	7	1	58	16	58	2,3	1,2	142	2	1	1
16	F	10	f	l	1	12	7	1	103	8	97	1,2,3	2,3,3,3	102	2.4	1	2
16	F	15	f	l	1	14	5	1	52	12	44	1,2	2,3	51	2.3	2	2
16	F	17	t	l	1	9	4	2	80	60	80	2,4	3,3,3,3	15	2.3	2	2
17	F	15	t	r	6	–	0	3	10	1	6	2,3	3	72	1	2	2
17	F	20	t	r	6	–	9	2	58	27	46	1,3,4	1,2,3,3	3	1	1	1
17	F	20	t	l	6	–	8.5	2	56	28	44	0	1,2	3	1	1	1
18	M	18	t	r	6	–	9.5	2	74	59	74	1,4,5	2	12	1	1	1
18	M	18	t	l	6	–	9.5	2	63	41	53	0	2	12	1	1	1
18	M	19	f	r	6	–	9	2	42	19	42	1,2,3	2,3,3	3	1	1	1
18	M	19	f	l	6	–	9	2	40	19	40	2	4	3	1	1	1
19	F	13	t	l	1	4	0	3	10	2	8	4,6	3	21	5	2	2
20	M	7	f	r	1	3.5	3.5	2	39	21	33	1,2,3	3	52	1	1	1
21	M	13	f	l	10	3	3	2	36	24	30	2	3	3	1	1	1
22	M	4	f	l	8	4	0	2	13	13	13	1	2	9	2	1	2
22	M	5	t	r	8	–	3	1	24	17	24	1	3	3	2	1	2
22	M	5	t	l	8	–	3	1	24	17	24	0	0	3	2	1	2
23	F	14	f	l	4	4.6	4.5	1	47	19	39	2,3	3,4,4,4	13	3	1	2
24	F	1	f	l	1	4	2	2	8	8	–	1.2	0	5	2	1	2
25	F	7	f	r	1	6	3.9	1	29	21	21	1,2,3	3,3	31	2	1	2
26	F	13	f	r	1	4	3	1	34	15	24	1,2,3	3,3,4	29	1	1	1
27	M	9	t	r	2	9	2	1	16	14	16	1,2	2,3	52	2	1	2
27	M	11	f	r	2	9.1	6	1	96	6	35	2	1	32	2	1	1
28	F	13	t	r	3	2.5	2.5	3	60	13	21	3	0	19	1	1	1

A Sex
B Age (years)
C Bone: f, femur, t tibia
D Side: r right, l left
E Cause: 1 congenital, 2 poliomyelitis, 3 trauma, 4 infection of joint, 5 osteomyelitis, 6 achondroplasia, 7 iatrogenic, 8 vascular physeal damage, 9 paralysis of ischial nerve, 10 M. Perthes, 11 unknown origin
F Preoperative discrepancy (cm)
G Achieved lengthening (cm)
H Method: 1 diaphyseal osteotomy, 2 metaphyseal corticotomy, 3 distraction physiolysis
I Complete radiographic consolidation (weeks)
J Time to removal of fixator (weeks)
K Time to full weight bearing without any external support (weeks)
L Complication: 0 none, 1 bone, 2 joint, 3 infection, 4 nerve, 5 muscle power, 6 emotional
M Additional surgery: 0 none, 1 removal of hardware, 2 other equalization procedure, 3 treatment of complication, 4 correction of preexisting anomalies/other surgical procedures
N Follow-up period (months)
O End result at last follow-up: 1 good, 2 residual discrepancy, 3 permanent restriction of motion of knee, 4 permanent restriction of motion of hip, 5 paralysis of peroneal nerve
P Premature cessation because of complications: 1 no, 2 yes
Q End result elongation: 1 satisfactory, 2 unsatisfactory

In Cases 13 and 16, elongations performed by us before 1980 were included to give a more complete picture.

Table 2. Patients with multiple elongations

Elongations	Patient (n)	Procedure (n)
Twice femoral	1	2
Ipsilateral femoral and tibial	2	4
Femoral and twice ipsilateral tibial	1	3
Triple femoral and ipsilateral tibial	1	4
Twice tibial and contralateral tibial	1	3
Ipsilateral femoral-tibial and contralateral tibial	1	3
Both femoral and both tibial	2	8
Total	9	27

Results

In 12 out of 23 cases with limb-length discrepancy, equalization was achieved in one procedure and in 2 cases in two procedures. In the other 9 patients, the discrepancy was too great to be corrected in one procedure or the occurrence of complications prohibited full correction. A partial correction averaging half of the deficit has been achieved. In the 5 patients with short stature, an average increase of 6.8 cm per lengthened bone was achieved. The mean follow-up period was 29 (2–150) months. There were differences between the three methods in the average time before removal of fixator per centimeter elongation: 3 weeks for diaphyseal osteotomy, 5 weeks for metaphyseal corticotomy, and 9 weeks for distraction physiolysis. The average time until full weight bearing per centimeter elongation was respectively 9 weeks, 8 weeks, and 12 weeks (not significant in analysis of variance, $P = 0.501$). The average time to radiographic consolidation per centimeter elongation was 11 weeks for diaphyseal osteotomy, 9 weeks for metaphyseal corticotomy, and 15 weeks for distraction physiolysis (not significant in analysis of variance, $P = 0.054$).

The final result was satisfactory in 16 of 28 patients and in 29 of the 46 procedures. The Wagner method was satisfactory in 12 and unsatisfactory in 11 procedures. Metaphyseal corticotomy was successful in 13 and unsuccessful in three procedures. Distraction physiolysis was satisfactory in 4 and unsatisfactory in 3 patients. The additional surgical procedures are given in Table 3. Only in 4 patients additional surgery was not necessary: 1 patient with a metaphyseal corticotomy, 1 with diaphyseal osteotomy, and 2 patients with a distraction physiolysis. The removal of plates, screws and nails, other lengthening procedures, and correction of preexisting anomalies can be considered as inevitable; so a total of 52 surgical interventions for a complication are left. This was required in 11 of 14 procedures for short stature versus 41 in 32 elongations performed for leg-length discrepancy. Also, it seems that the diaphyseal osteotomy group had a higher rate of surgical interventions than the other two methods.

Complications

Only four procedures had no complication: one femoral and three tibial lengthenings, of which 3 patients were of short stature.

Systemic complications were emotional problems in 4 children. In Case 19, this led to premature cessation of the lengthening, whereas the other 3 children were helped by a psychologist.

No cases of thrombosis and embolism or circulatory disturbances occurred.

Bone. The most frequent bone complication was axial deviation (Table 4). In femoral elongations, there were five varus deformities (average 15°), three valgus deformities (average 15°), and two antecurvations (average 19°). In tibial lengthenings, valgus deformity developed five times (average 12°), varus deformity two times (average 11°), and antecurvation two times (average 12°). In Case 7 with achondroplasia, a correction osteotomy after complete consolida-

Table 3. Additional surgery in 24 patients (42 procedures)

Procedure	Diaphyseal osteotomy (16 patients–23 procedures)		Metaphyseal corticotomy (10 patients–15 procedures)		Distraction physiolysis (5 patients–5 procedures)	
	LLD	SS	LLD	SS	LLD	SS
Removal of plate, screws, and nails	9	2	–	2	–	–
Other lengthening procedures	9	–	–	7	–	–
Treatment of complication	28	2	7	8	6	1
Other	5	–	1	1	–	–

LLD limb-length discrepancy, SS short stature.

Table 4. Local complications of 46 lengthening procedures in 28 patients

Nature	Femur (n 24)		Tibia (n 22)		
	MC (n 7)	DO (n 17)	MC (n 9)	DO (n 6)	DE (n 7)
1. Bone					
delayed union	–	3	–	–	–
nonunion	–	–	1	1	–
axial deviation	2	8	4	3	2
late fracture	–	3	–	4	–
loss of length	1	2	1	–	1
premature consolidation	2	1	–	2	–
2. Joints					
a. restriction of motion					
hip	2	2	–	–	–
knee	5	14	2	1	2
ankle	–	2	1	3	3
b. (sub)luxation					
hip	–	1	–	–	–
proximal tibia	–	2 (sub)	1	–	1 (sub)
patella	–	1	–	–	1 (sub)
3. Infection					
wound	–	1	–	–	–
pin-track	2	10	1	1	2
osteomyelitis	–	–	1	–	–
4. Nerves					
n. peroneus paresis	–	–	6	–	1
n. peroneus hyperalgesia	–	–	1	–	–
5. Loss of muscle power	–	1	3	–	–
6. Complication leading to discontinuation of lengthening procedure					
serious restriction of motion of hip	–	1	–	–	–
dislocation of hip	–	1	–	–	–
dislocation of proximal tibia	–	–	1	–	–
emotional problems	–	–	–	–	1
atypical fracture of the physis	–	–	–	–	1

MC metaphyseal corticotomy, DO diaphyseal osteotomy, DE distraction physiolysis.

tion was needed. The other 18 axial deviations were treated by manipulation under anesthesia with adjustment of the fixator, or by correction at the time of osteosynthesis.

Late fracture of a femur with delayed union was caused in Case 5 by a fall, and was treated by internal fixation and bone grafting. Femoral fracture above the AO plate occurred twice after prolonged nonweight bearing in 1 patient. The fractures were treated conservatively and healed. Late fracture of the tibia occurred in 3 patients: 2 were treated conservatively and healed uneventfully. Case 14 had two late fractures: a nonunion was treated with bone grafting and screws, and thereafter, one spontaneous fracture and one fracture after a minor trauma were treated conservatively and ultimately healed.

Loss of length occurred in 5 patients. This was caused in the femoral elongations two times by osteosynthesis (intramedullary nail and plating) and once during changing of the fixator, which was necessary for correction of an axial deformity. The loss averaged 1.3 (0.5–2) cm. In the tibial lengthenings, loss of 1–1.5 cm occurred once during changing of the fixator and once after the beginning of weight bearing.

Premature consolidation was encountered in 5 patients. This phenomenon was observed particularly in very young children.

Joints. Transient slight restriction of motion of the adjacent joints occurs in almost all the lengthening procedures. Serious restriction of hip motion was observed four times: it was transient in 3 patients after intensive exercises with a physiotherapist and permanent in Case 16 with a congenital short femur; dislocation of the hip developed in the distraction period, required acetabuloplasty, and led to a permanently stiff hip after a second dislocation.

Serious restriction of motion of the knee was seen in 17 patients, remaining permanent in 5, with an average of 33° (15°–50°). In one tibial distraction physiolysis, the patella was dislocated downward by traction of patellar tendon fibers, which had remained attached to the distal part of the fractured tibial tuberosity after anomalous separation of the physis. This was successfully treated with transverse section of these distal

fibers. One habitual patellar dislocation was left untreated because of lack of symptoms. In 1 patient a posterior subluxation of the tibia occurred twice during femoral and tibial lengthening, and was treated with traction on the tibial tuberosity, after which good function was obtained. In Case 16 a posterior subluxation of the tibia developed twice when a tibial lengthening followed a femoral elongation. This was also treated with traction on the tibial tuberosity, but a complete posterior dislocation of the proximal tibia developed with a permanent restriction of motion and development of arthrosis.

Serious restriction of motion of the ankle was transient in six and permanent in three procedures (average 30°, range 25°–35°).

Infection. One wound infection occurred in a femoral lengthening after osteosynthesis with a plate. This led to a fistula that did not influence the consolidation and was cured after plate removal. One case of osteomyelitis developed after a pin-track infection and later internal fixation with an intramedullary nail in a patient with achondroplasia. This osteomyelitis was cured at complete consolidation and nail extraction. The pin-track infections were all treated successfully with skin release under local anesthesia and/or antibiotics.

Nerves. All the neurologic complications except one were transient, and the symptoms disappeared when speed of lengthening was reduced temporarily. However, in Case 19 a total peroneus palsy occurred with symptoms 10 days after the operation; the patient had a 35° valgus of the knee and shortening of the tibia. After distraction physiolysis the valgus was corrected, but subsequent lengthening was not achieved because of emotional problems, which led to premature cessation of the procedure. This palsy was probably caused by factors related to pin placement and correction of valgus deformity.

Loss of muscle power was evaluated only by clinical examination and was observed four times—transient in each instance.

Discussion

Although the final results of leg-lengthening procedures were satisfactory in more than half of the patients, a considerable number of complications were encountered with all three techniques. In this study, metaphyseal corticotomy had more often a satisfactory result than diaphyseal osteotomy or distraction physiolysis. Diaphyseal osteotomy involved more cases of delayed union, late fracture, and axial deviation. This is in agreement with other authors. De Bastiani et al. (1987) reported a high incidence of revisions (89 operations to lengthen 27 segments) and 26 percent complication rate with the Wagner method, which was halved when callus distraction (callotasis) was used. Monticelli et al. (1983) reported 21 complications in 43 elongations by metaphyseal corticotomy. In comparison Hood et al. (1981) noted 37 complications in 40 procedures by the Wagner method. Wagner (1978) described 89 concomitant operations to lengthen 58 patients with a complication rate of 45 percent. During recent years, there have been several reports of superior results of lengthening after corticotomy and callotasis and by using other frames, such as the Orthofix (De Bastiani et al. 1986, 1987), which gives the possibility of dynamization and the Ilizarov frame (Monticelli and Spinelli 1983, Cambras et al. 1984, Paley 1988). These frames seem to give better results than the fixators used by us: Wagner, Hoffman, and our own special lengthening design.

When comparing the times to removal of fixator and bone healing in distraction physiolysis to those of Monticelli and Spinelli (1981), these periods were more than twice as long in our study. We believe this can partly be explained by the fact that there is no hard criterion for making the decision to remove the fixator or stop the cast protection. Monticelli and Spinelli (1981) used an empirical criterion of 70 percent ossification of the lengthened zone on CT, and reported in 2 of their 16 cases crushing of the newly formed cortex. So when we introduced the new method of distraction physiolysis, we were very careful in removing the fixator and allowing unprotected weight bearing.

Our own idea of internal fixation by an intramedullary interlocking nail to decrease time of nonweight bearing should be abandoned for two reasons. It requires an extra operation: application of skeletal traction to maintain length when the fixator is removed to let pin tracks heal. Also, serious complications were encountered, namely, loss of length and 1 case of osteomyelitis.

The total number of 119 complications in 46 procedures appears to be high compared with other studies (Gross 1971, Coleman 1978, Manning 1978, Wagner 1978, Armour 1981, Hood 1981, Monticelli 1981, De Bastiani 1987). However, this difference can partly be explained by semantic factors: some authors distinguish between problems and complications. Problems are intrinsic, cannot be avoided, and must be dealt with (Wagner 1978, Coleman 1978), e.g., delayed union and nonunion, pin-track infections, and transient restriction of motion in adjacent joints. Complications are extrinsic and should be avoided, notably infection of osteotomy, nerve damage, fractures, and (sub)luxations. Others distinguish between minor and major complications (Gross 1971, Hood

1981) or do not mention infectious skin problems at all (Manning 1978). If we disregard pin-track infections, delayed union, nonunion, and transient problems, such as restriction of motion, loss of muscle power, emotional problems, and neuropraxies as true complications, our complication number drops to 45.

Another complicating factor in comparing the results of different studies is the difference in composition of the patient groups. In our study, 12 patients had a congenital anomaly of the leg, and 19 of the 46 procedures were performed for this reason. This group is known as the most difficult one to achieve substantial elongation in (Besselaar 1989). Further, in 12 patients a previous lengthening procedure had already been carried out. Only 5 patients (14 procedures) were treated for short stature. A lower complication rate occurred in this group. This is probably related to the better initial status of the bones and soft tissues in patients with short stature.

In contrast to others (Sofield 1958, Kawamura 1968), serious problems with loss of muscle power were not encountered. These authors had a majority of patients in which the leg-length discrepancy was due to poliomyelitis. In none of our polio patients, did muscle power deteriorate. The most serious complications were (sub)luxating joints. In retrospect the dislocation of the hip could probably have been avoided if the acetabuloplasty had been carried out before femoral lengthening. The same patient developed gonarthrosis after posterior dislocation of the proximal tibia and probably should not have had a tibial lengthening after a previous femoral lengthening because of aplasia of the cruciate ligaments. The other (sub)luxations could be satisfactorily dealt with. We agree with Wagner (1978) that instability of the adjacent joints must be corrected before a lengthening procedure is started.

The large number of axial deviations may be reduced by more attention to proper placement of the distraction apparatus.

In conclusion, a leg lengthening is a complicated procedure, which requires adequate selection of patients, good preoperative examination and planning, and meticulous attention to the details in surgery and aftercare. In our hands, elongation by metaphyseal corticotomy led more often to a satisfactory result and was accompanied by a lower rate of serious complications than lengthening by diaphyseal osteotomy. This suggests that metaphyseal corticotomy should be preferred. In any case, leg-lengthening procedures should be carried out only in specialized centers.

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