Unchanged muscle function after bilateral femoral lengthening

A prospective study of 9 patients with a 2-year follow-up

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We performed pre- and 2–3.5-year postoperative isokinetic knee-testing to assess thigh muscle function in 9 patients undergoing bilateral femoral lengthening by callotasis. The median femoral lengthening was 17 (12–18) percent. The angular testing velocities were 60°/sec (strength) and 180°/sec (endurance).

Only small changes in muscle strength were found postoperatively. Except for peak torque at 60°/sec on the last-operated side (median 2 years follow-up), there were no differences between the pre- and postoperative isokinetic measurements. There were 3 major complications, 2 fractures and 1 varus deformity. 2 patients had problems with patellar pain. All patients achieved normal range of motion. They judged the final result as very good and underlined the psychological effect and the practical advantages of being taller.

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Lengthening of the femur may be indicated both in leg-length discrepancy and in young persons of short stature. To our knowledge, no one has prospectively studied muscle performance, including objective measurements of function after lengthening.

Aldegheri et al. (1989) in a study of 146 femoral lengthenings found that joint function and muscle power recovered in all cases, but the evaluation of function was not described. Price and Cole (1990) included strength-testing in a follow-up evaluation, but no objective measurements were reported. Renzi-Brivio et al. (1990) concluded that it is more important to retain complete limb function than to achieve full corrective lengthening at all costs. The importance of physiotherapy after lengthening was underlined by Aldegheri et al. (1989). We studied limb performance pre- and postoperatively in 9 patients with bilateral femoral lengthenings.

Patients and methods

From 1989 to 1992, 9 short-statured persons underwent bilateral lengthening osteotomies. There were 7 girls and 2 boys. The median age was 15 (12–21) years and the median preoperative height was 147 (144–156) cm.

All lengthenings were performed in the femur by a transverse osteotomy of the proximal metaphysis. A unilateral Orthofix device was used for external fixation and distraction (Aldegheri et al. 1988). The limbs were operated on one at a time. The distraction rate was 1 mm per day by 4 increments of 0.25 mm. Removal of the fixator was done at the time of solid consolidation of the lengthening zone. The total treatment time (distraction time + consolidation time) used for each segment was 10 (8–14) months. The median femoral lengthening was 7.7 (5.6–8.6) cm, giving a relative lengthening (lengthening/original length × 100) of 17 (12–18)%. The median postoperative observation times for the first- and last-operated limbs were 42 (27–56) and 27 (16–43) months, respectively. There were 3 major complications; 2 femoral fractures through the lengthening zone, which occurred just after removal of the fixator and 1 varus deformity which was operatively corrected. All 3 femurs were treated with an intramedullary nail and healed secondarily.

Muscle performance was tested isokinetically in knee extension and flexion on a Cybex 340 dynamometer (Cybex-Lumex Inc, Ronkonkoma, New York). Quadriceps and hamstring muscles were tested preoperatively and again after 2 years or more, when consolidation of the lengthening zone had occurred. Prior to testing, each subject bicycled for 8 min on an ergometer cycle. The patients were fixed to the apparatus with straps securing the chest, pelvis, thigh and ankle. Both limbs were tested, the dominant

Table 1. Main characteristics and muscle performance in 9 tested patients

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	16.9 / F	148	80	60	100	154	75	100	133	1002	223	1595	110	829	208	1604
2	12.7 / F	150	40	150	100	160	5	78	134	584	206	850	122	767	188	1399
3	14.8 / F	147	60	10	100	155	67	100	110	862	210	1101	82	734	160	1124
4	21.9 / M	156	60	10	100	161	79	83	176	1381	296	1549	120	849	212	1161
5	13.0 / F	145	60	60	100	153	92	100	67	412	192	890	84	492	143	852
6	13.5 / F	147	55	130	100	156	81	100	101	698	158	1121	65	442	100	953
7	15.8 / M	150	70	30	100	158	100	100	152	1132	254	1408	129	1163	211	1847
8	15.8 / F	144	60	40	98	151	82	72	100	749	194	974	101	875	180	1307
9	15.7 / F	147	80	10	100	155	100	100	86	728	169	1143	79	669	144	1016

A Age / sex
B Preoperative height (cm)
C Operation time (min)
D Peroperative blood loss (ml)
E Preoperative function (VAS)
F Postoperative height (cm)
G Postoperative function (VAS)
H Subjective result (VAS)

I–P, last-operated leg
I Preoperative peak torque (PT) hamstrings 60°/sec (Nm)
J Preoperative total work (TW) hamstrings 180°/sec (Joule)
K Preoperative PT quadriceps 60°/sec (Nm)
L Preoperative TW quadriceps 180°/sec (Joule)
M Postoperative PT hamstrings 60°/sec (Nm)
N Postoperative TW hamstrings 180°/sec (Joule)
O Postoperative PT quadriceps 60°/sec (Nm)
P Postoperative TW quadriceps 180°/sec (Joule)

side first. During testing, the range of knee motion was limited from 0° to 90°. The test protocol consisted of 5 repetitions at an angular velocity of 60°/sec, followed by a 1 min rest period. Thereafter, 25 repetitions at 180°/sec were performed. Isokinetic parameters used for evaluation of muscle function were peak torque at 60°/sec (strength) and total work at 180°/sec (endurance).

At the postoperative test, the patients were asked to give their opinion of function of the lower limbs pre- and postoperatively and the overall result of the surgery on a visual analog scale (VAS). The patients underwent manual tests for knee stability and were asked about patellar pain. Problems with walking, stair-climbing and running were recorded.

Distributions were expressed by median and range and differences between the pre- and postoperative data were compared by nonparametric statistics (Wilcoxon matched-pair signed-ranks test). Values of $p < 0.05$ were considered significant.

Results

All patients achieved normal range of motion postoperatively. Small changes in muscle strength were found postoperatively for both muscle groups (Table 1). Except for quadriceps peak torque at 60°/sec (last operated femur) which showed a reduction of 17% ($p < 0.01$), there were no differences between the pre- and postoperative isokinetic measurements (Table 2). The reduction was more pronounced for peak torque than for total work.

The median VAS score for function pre- and postoperatively was 100 (98–100) and 81 (5–100), respectively. For the patient's subjective opinion of the overall result, the median score was 100 (72–100). 2 patients had patellar pain and difficulties with stair-climbing and running. One of them could not walk 1 km to school.

Table 2. Median (interquartile range) and relative change as a percentage of preoperative value for peak torque and total work for quadriceps and hamstrings on last-operated leg in 9 patients before and after lengthening

	Quadriceps		Hamstrings	
Time	PT[a]	TW[b]	PT	TW
Preop	206 (192–223)	1121 (974–1408)	110 (100–134)	749 (698–1002)
2 years	180 (144–208)	1161 (1016–1399)	101 (82–120)	767 (669–849)
Relative change %	−16.9* (−25.5–8.7)	0.6 (−31.2–11.1)	−15.1 (−25.5–8.1)	−8.1 (−17.3–16.8)

[a] peak torque (Nm) at 60°/sec
[b] total work (Joule) at 180°/sec
* $p < 0.01$

Discussion

At 2 years postoperatively, only one single parameter (quadriceps peak torque at 60°/sec) of the last operated limb showed a reduced muscle strength. We expect this reduction will be eliminated over time, because the first operated limb with an average of 1 year longer observation time showed no differences from the preoperative data. These findings may be surprising, as it is a common clinical impression that, at least early after a limb-lengthening procedure, there is a considerable loss of muscle strength that may last for a long time.

It has been suggested by Lindboe et al. (1985) that limb-lengthening may cause unphysiological stretching of skeletal muscles and that lengthening osteotomies in sheep can lead to muscle atrophy. Our clinical findings are in contrast to their short-term experimental findings which showed that 10–20% lengthening led to a 44% reduction in type 2 fiber area at 10 weeks postoperatively. In our study, the relative lengthening was 17%, but we found no long-time reduction in strength either at the angular velocity of 60°/sec or at 180°/sec.

Our results correspond well to the findings of Leivseth and Reikerås (1992) in rats: at 3 months postoperatively there was no reduction in the cross-sectional area after a 13% lengthening. They concluded that muscles are capable of adapting to bone lengthening, thereby preserving the cross-sectional area.

Our clinical experience is that during the lengthening procedure there is a temporary loss of function, due to joint contractures, pain and reduced weight bearing. On the basis of early registrations the functional outcome is rather poor, but after 2–3 years the function is restored. Our findings indicate even a progress in muscle function from 2–3 years postoperatively, as no reduction in performance was found for the first-operated limb with a median observation time of 3.5 years.

In spite of the fact that 3 major complications occurred and that 1 patient still has severe functional disturbance because of patellar pain, the median VAS score for the patients' subjective opinion of the overall result was 100. When asked if they would go through this procedure again today, everyone said yes. They all underlined the psychological effect and the practical advantages of being 5–10 cm taller. The scars and the disproportion between the thigh and the leg did not bother them (Figure 1).

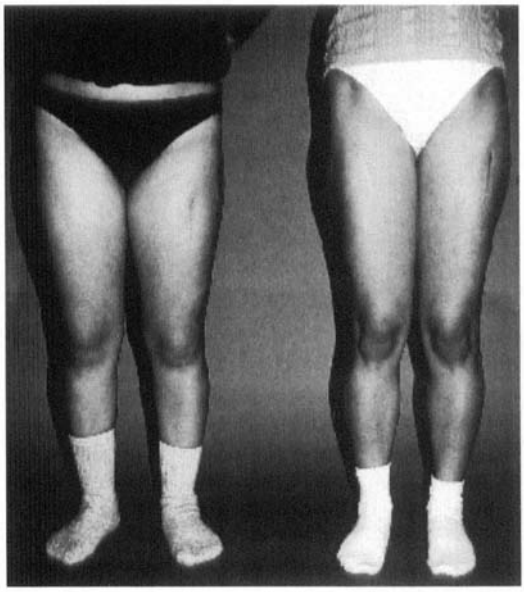

Figure 1. Patients 8 and 9. Proportion between the thigh and the leg following bilateral femoral lengthening osteotomies.

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