Influence of femoral lengthening on hip joint space in posttraumatic femoral shortening

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We performed femoral lengthening for post-traumatic femoral shortening in 14 patients (10 men). The mean age was 26 (17–33) years. The callotasis method was employed using an Orthofix or a Hifixator monolateral external fixator. The average length gained was 6 (3–13) cm, equal to 16 (7–36)%.

The mean narrowing ratio of the hip joint space during lengthening was 9 (0–26)% and the narrowing persisted at the final follow-up. Cases with narrowing greater than 5% had a longer time between the development of the shortening and the lengthening than the others ($p = 0.03$).

Our findings indicate that femoral lengthening for posttraumatic femoral shortening should be done as early as possible to prevent the development of joint space narrowing during the lengthening procedure.

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The increment of muscle tension across the two fragments of a leg bone during lengthening has been noted in several studies (Onishi et al. 1991, Aronson and Harp 1994, Younger et al. 1994), and the compressive pressure on the hip articular surface has been found to increase during femoral lengthening in a study performed on a cadaver (Olney and Jayaraman 1994). Cartilage damage of adjacent joints has therefore been pointed out as a possible complication (Paley 1990), and has also been shown in animal experiments (Nakamura et al. 1993, Stanitski 1994).

Clinical experience has been limited, however, except in one study which reported joint space narrowing of the hip in 3 cases of femoral lengthening (Hiroshima 1991). It is believed that limb lengthening to restore a shortened limb to its original length generates less tension on soft tissue than that for short stature (Simpson et al. 1996), but the possible risk of inducing cartilage degeneration in leg lengthening for posttraumatic shortening is unknown.

We analyzed whether hip joint space narrowing develops during limb lengthening for posttraumatic femoral shortening.

Patients and methods

We performed a retrospective study on patients with posttraumatic femoral shortening whose femoral lengthening had been completed between 1982 and 1994 in our hospital. Patients with associated congenital limb disease, a history of hip lesions or lower limb neurovascular diseases were excluded.

The etiology of the femoral shortening was a femoral fracture in 11 and a distal femoral physeal injury in 3 patients. The mean age at lengthening was 26 (17–33) years, and the average period from development of femoral shortening to the beginning of lengthening, was 6 (1–19) years. The callotasis method (Ilizarov 1990) was employed for the lengthening using an Orthofix monolateral external fixator (6 femurs) or a Hifixator monolateral external fixator (9 femurs). Lengthening began after callus appearance (14–22 days) at an initial rate of 1 mm per day in 2 or 4 increments and the lengthening rate was then adjusted according to the amount of callus formation and joint motion; the mean rate of each lengthening eventually reached 0.6 mm/day (0.3–0.9 mm/day). Physiotherapy during lengthening included functional loading, and motion exercise of hips and knees. The average length gained was 6.3 (3–13) cm, an average gain ratio of 16 (7.2–36)% (Table 1). The mean follow-up period after removal of the external fixator was 19 (2–43) months.

Anteroposterior radiographs of both hip joints taken in a supine position prior to lengthening, at the removal of the external fixator and at the final follow-up were used for analyses. The radiolucent area between the lunate surface of the acetabulum and the apposing femoral head, corresponding to the articular

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Table 1. Clinical data

A	B	C	D	E	F	G	H	I	J	K
1	F	26	H	0.41	12	4.5	12	–	39	0
2	M	32	O	0.54	11	4.5	11	–	14	1
3	M	22	H	0.74	3	7	17	–	60	1
4	M	33	H	0.53	1	3.1	7	–	10	2
5	F	33	O	0.54	30	6.1	17	–	10	2
6	M	29	O	0.49	26	8.5	20	–	40	3
7	F	27	H+O	0.36	15	6.3	19	+	134	6
8	M	29	O	0.50	26	5.7	14	+	179	8
9	M	22	H	0.79	38	9.9	25	+	120	10
10	M	29	H	0.45	23	4.5	10	–	36	11
11	F	27	O	0.47	25	5	12	–	18	14
12	M	20	H	0.34	–4	3	7	+	131	17
13	M	17	H	0.89	2	7.5	20	+	49	19
14	M	24	H	0.71	11	13	36	+	228	26

A Case no. in previous publication (Hung et al. 1996)
B Sex
C Age at lengthening, years
D Monolateral external fixator
  H Hifixator
  O Orthofix
E Mean lengthening rate, mm/day
F Narrowing ratio before lengthening, %
G Length gained, cm
H Ratio length gained, %
I Hip contracture, ≥ 10°
J Months from femoral shortening to the beginning of lengthening
K Narrowing ratio during lengthening, %

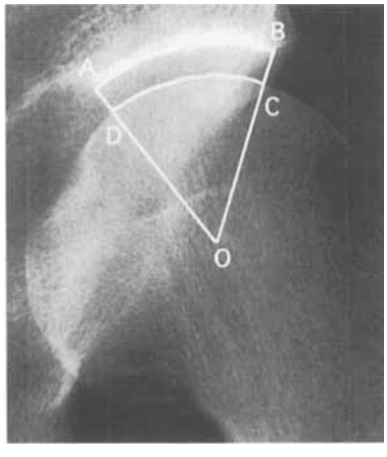

Figure 1. Measurement was made as the area of lucency ABCD, between lines AO and BO from the center of the femoral head (O), to the lateral (B) and medial (A) margins of the lunate surface of the acetabulum. When the angle AOB could not be clearly determined in some cases of lengthening due to blurred medial margin A, the angle AOB from the contralateral, normal side was used to determine line OA and point A for the lengthening side.

cartilage in anatomy, was measured by the method of Teshima et al. (1992) as shown in Figure 1. We used the Photoshop computer program and the NIH Image program as in the previous report (Hung et al. 1996). The area ratio of the lengthening side to the normal side (AR) and the narrowing ratio before (NRB) and during lengthening (NRD) were calculated:

AR (%) = (area of the lengthening side / area of the normal side) × 100;
NRB (%) = (1–AR before lengthening) × 100;
NRD (%) = (AR before lengthening – AR on removal of the external fixator) × 100.

Hip ROM was evaluated before lengthening, and was closely observed during lengthening and after removal of the external fixator. Hip subluxation, dislocation and findings associated with arthrosis or other specific diseases were also checked radiographically.

Statistical differences were analyzed using the Friedman test first and then the Wilcoxon signed-ranks test for AR changes and the Mann-Whitney U-test for other group differences. P-values < 0.05 were considered significant.

Results

The values of AR were 62–104% before lengthening, 52–97% on removal of the external fixator, and 52–98% at the final follow-up (Figure 2). The difference between these three measurements was significant ($p < 0.001$), as was that before lengthening and on the removal of the external fixator ($p < 0.005$), while that between removal of the external fixator and at final follow-up was not. The mean value of NRD was 9 (0–26)%, and 5% or more in 8 of 14 patients (Table 1).

Patients were divided into two groups to investigate the possible causes of joint space narrowing during lengthening: one with narrowing exceeding 5% during lengthening and the other with less severe reduc-

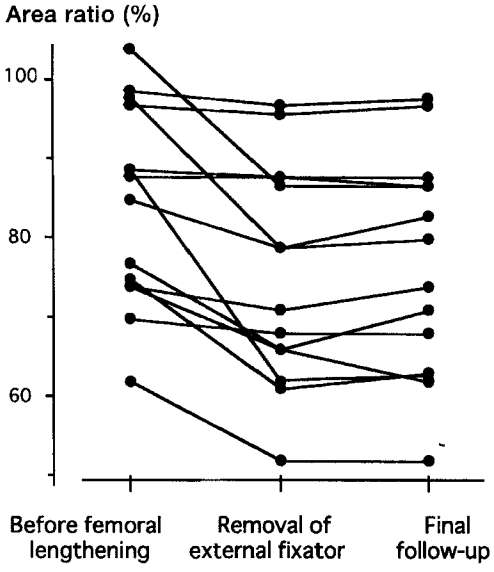

Figure 2. Changes in hip joint space area following femoral lengthening. The Friedman test was first used with the difference among these found significant three times ($p < 0.001$), then Wilcoxon signed-ranks test was used which showed that the difference between before lengthening and at removal was significant ($p < 0.005$) but not the difference between removal and final follow-up.

tion. Narrowing during lengthening was not significantly associated with narrowing which existed before lengthening, age at lengthening, length gained, or the ratio of length gained during lengthening. It was, however, related to the period from the development of femoral shortening to the beginning of femoral lengthening: 112 months for cases with NRD more than 5% and 29 months for those less than 5% ($p = 0.03$) (Table 2).

Hip flexion contracture or ROM restriction of more than 10 degrees during the lengthening procedure was noted in 6 patients; all but one recovered before removal of the external fixator. The mean NRD was 16% for cases with hip joint contracture during lengthening and 4% for those without the contracture ($p = 0.02$) (Table 3).

None of the hip joints showed subluxation, dislocation, or any sign of arthritis, such as the formation of osteophytes in the femoral head or acetabulum.

Discussion

In patients with posttraumatic femoral shortening, the joint space of the hip was narrowed before femoral lengthening, as we have previously reported (Hung et al. 1996). We now found that the joint space narrowed during lengthening, though the leg merely regained its original length. Development of joint space narrowing was correlated with the period of shortening before lengthening was undertaken. Since it is known that muscle tension can adapt to a new length with time (Nordsletten et al. 1992, Holm et al. 1994), these findings can be explained by the adaptation of muscle

Table 2. Comparison of data between groups with narrowing ratio during lengthening more (n 6) or less (n 8) than 5%. Mean, range

	Narrowing ratio during lengthening < 5%	> 5%	P-value of difference
Narrowing ratio before lengthening, %	14 (1–30)	17 (–4–38)	0.8
Age at lengthening, years	29 (22–33)	24 (17–29)	0.08
Length gained, cm	5.6 (3.1–8.5)	6.9 (3–13)	0.5
Ratio of length gained, %	14 (7–20)	18 (7–36)	0.5
Period, months [a]	29 (10–60)	112 (18–228)	0.03

[a] Period from femoral shortening to the beginning of lengthening. Mann-Whitney U-test

Table 3. Comparison of data between groups with and without hip contracture. Mean, range

	No hip contracture n 8	Hip contracture n 6	P-value of difference
Narrowing ratio during lengthening, %	4 (0–14)	16 (6–37)	0.02
Period, months [a]	28 (10–60)	140 (49–228)	0.03

[a] Period from femoral shortening to the beginning of lengthening. Mann-Whitney U-test

tension. We therefore suggest that limb lengthening for posttraumatic shortening should be done as early as possible to reduce problems with the adjacent joints.

The presence of joint contracture was also related to the development of joint space narrowing during lengthening, and we believe that both this condition and joint space narrowing of the hip can be caused by increasing soft tissue tension during lengthening. The possibility that joint contracture itself aggravated the joint space narrowing can not be excluded, however, because it has been shown that immobilization can have negative effects on articular cartilage (Evans et al. 1960).

There was no significant association between joint space narrowing and length or ratio of length gained during lengthening. This may be because the ratio of length gained was within a relatively small range, usually from 10% to 20%.

Cases 5 and 6 which had severe joint space narrowing before lengthening showed no increase of the narrowing during lengthening or at follow-up. Further, there was no association between the presence of joint space narrowing before lengthening and its development during lengthening. Therefore, at the present time, narrowing before lengthening should not be considered a contraindication to limb lengthening. Since no cases showed osteophyte formation at follow-up, the clinical significance of joint space narrowing remains to be determined.

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