

# Spontaneous correction of femoral torsion

## Diaphyseal osteotomies studied in kittens

Inward or outward torsion of about 25 degrees was produced in the right femur of kittens by midshaft osteotomy and plate fixation. The left femurs served as controls. The anteversion angle of the femoral necks was measured in axial radiographs taken preoperatively and up to 58 weeks postoperatively. As the bones grew in length, the difference in the anteversion angle between matched femurs was gradually corrected.

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### Introduction

Femoral shaft fractures in children may heal with torsional deformity, and many investigators claim that no spontaneous correction occurs during growth (Vontobel et al. 1961, Weber 1969, Verbeek et al. 1976, Benum et al. 1979); a special traction frame for torsional controlled immobilization of children with femoral shaft fractures has been advocated (Weber 1969). However, other authors have reported correction by growth of torsional deformities (Laer 1977, Verbeek 1979, Brouwer et al. 1981, Hägglund et al. 1983).

We have studied the effects of growth on torsional deformities of the femur following osteotomy in kittens.

### Materials and methods

Sixteen kittens (6 female and 10 male) were used. At the start of the experiment, they were 13 weeks old and their median weight was 1 (0.7-1.4) kg. They were housed in an open colony at room temperature and were given standard laboratory cat food and water ad libitum.

The rotational mobility of the hips in four additional 12-week-old kittens was assessed. Except for this assessment, these kittens were not included in this study.

### Design of experiment. (Table 1)

In a preliminary study, we used rabbits, but the femur invariably broke soon postoperatively (Skandfer & Sudmann 1976). Femoral torsion was produced on the right side by mid-diaphyseal osteotomy, rotation of the distal fragment inwards or outwards, and plate fixation. The left femur served as a control. It was assumed that the difference between measurements of the anteversion (AV) angle ( $\alpha$ ) of the femoral neck of matched

Table 1. Design of experiment

	Radiographic examination (weeks)						
	preop	0	3	12	24	44	58
Outward (8)	8	8	8 <sup>a</sup>	7	7	7	1
Inward <sup>b</sup> (8)	4	4	4	4 <sup>c</sup>	3	3	1

The figures in the table refer to the numbers of animals.

<sup>a</sup> One animal died under anesthesia.

<sup>b</sup> The osteosynthesis failed in 4 animals, which were excluded.

<sup>c</sup> One animal had to be killed because of wound infection.

femurs reflected the rotation on the right side.

In the outward rotated group the immediate postoperative AV angles were smaller than the controls, whereas in the inward rotated group the right angles were the larger ones. Thus, the difference between matched right and left AV angles was a negative value in the outward rotated group (Table 2).

### The osteotomy

Under general anesthesia (Pentobarbital sodium 50 mg/kg s.c.) and sterile conditions, the right femoral shaft was exposed subperiosteally through a lateral longitudinal incision, and the site for the osteotomy marked on the bone. By means of a template, four holes were drilled for the screws of the osteosynthesis plate; one pair of parallel holes on either side of the planned osteotomy. The two pairs formed an angle of about 25 degrees with each other in order to obtain a torsion deformity of this magnitude. For a marker screw, a fifth hole was drilled in the proximal fragment parallel to the pair of holes in the distal fragment (Figures 1 and 2).

After a transverse osteotomy was made with a circular dental saw, the distal fragment was rotated 25 degrees either outwards or inwards. A straight, five-hole osteosynthesis plate (Synthes, Waldenburg, Switzerland) was

Table 2. Anteversion angle of femoral neck (degrees)

Group	Side	Preop	Weeks after osteotomy				
			0	3	12	24	44-58
Outward	Right	24 (16-31) n=7	1 (0-8) n=8	11 (7-21) n=6	14 (10-26) n=7	19 (15-20) n=5	20 (15-25) n=6
	Diff	0 (-7-4) n=7	-20 (-28--16) n=7	-12 (-13--5) n=5	-9 (-20-0) n=6	-4 (-9-8) n=5	-1 (-7-1) n=7
Inward	Right	27 (17-32) n=4	54 (42-65) n=4	40 (40-45) n=3	31 (27-35) n=4	26 (22-28) n=3	26 (22-28) n=3
	Diff	0 (-2-4) n=4	27 (23-41) n=4	17 (13-24) n=3	6 (2-14) n=4	0 (-6-6) n=2	4 (-5-8) n=3
Both	Left	24 (19-33) n=9	24 (19-32) n=9	24 (19-28) n=9	24 (17-30) n=9	23 (20-28) n=7	25 (22-28) n=8

Median values. Ranges in parentheses.

Diff=difference in AV angle between matched right and left femurs.

The number (n) of available radiographs for analysis varied; two animals died (see Table 1) and some angles could not be assessed for technical reasons.

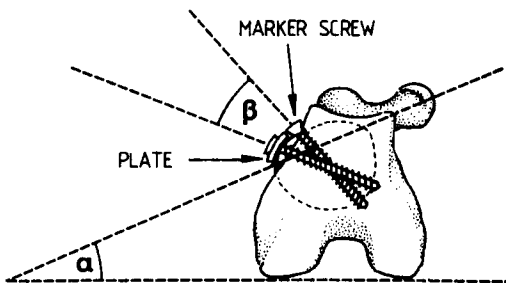


Figure 1. Right femur. The AV angle of the neck of the femur ( $\alpha$ ) and the angle between the marker screw in the proximal fragment and the proximal osteosynthesis screw in the distal fragment ( $\beta$ ) are indicated.

applied and fastened with four screws, 2.0 mm in diameter (Figures 1 and 2).

A fifth additional screw, inserted in the hole proximal to the plate, served as a marker. The angle ( $\beta$ ) between the marker screw and the proximal osteosynthesis screw in the distal fragment, as seen axially, indicated the torsional deformity (Figure 1). The wound was closed in layers.

## Radiographs

The AV angle of both femoral necks was measured in axial radiographs taken preoperatively and up to 58 weeks postoperatively (Table 1). Under general anesthesia the kittens were placed supine in a special frame,

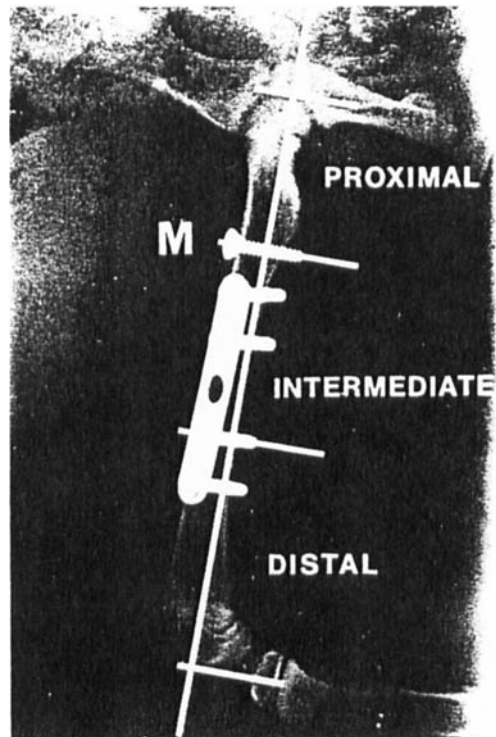


Figure 2. Right femur immediately postoperatively. A marker screw (M) was inserted in the proximal fragment to facilitate assessment of regression of torsional deformities.

with the hip and the knee joints flexed to 90 degrees, and the femurs positioned by fluoroscopy for axial radiography. In the axial radiographs the AV angle of the femoral neck ( $\alpha$ ) was defined as the angle between the posterior femoral condylar tangent and the axis through the center of the femoral head and centrally through the neck of the femur, respectively (Figure 1).

In lateral radiographs the longitudinal axis of the femur was drawn from the midpoint of the shaft at the trochanteric level to the midpoint of the distal epiphyseal plate. The length of the femur was measured from the head of the femur to the condyle most distal on the longitudinal axis.

To measure the femoral growth in length, perpendicular lines were drawn on the longitudinal axis through the proximal osteosynthesis screw in the distal fragment, and through the marker screw in the proximal fragment. Thus, the femur was divided into a proximal, an intermediate, and a distal segment (Figure 2). In the dissected femurs, to assess possible postoperative deterioration at the osteotomy site, i.e., failure of the osteosynthesis, these two screws were replaced by pins for exact identification for measurement of the  $\beta$ -angle between them in axial radiographs (Figure 1).

To assess the precision of the measurements of the AV angle in vivo, results from undissected and dissected specimens were compared. The radiographs were evaluated by the authors independently of one another. The difference between the AV angle in radiographs of (dead) undissected and dissected femurs and between two consecutive measurements in the same radiograph was less than 5 degrees and 3 degrees, respectively.

In axial radiographs of *dissected* right femurs, the  $\beta$ -angle between the marker screw in the proximal fragment and the proximal osteosynthesis screw in the distal fragment indicated whether or not the initial rotational dislocation had been retained (Figure 1). The  $\beta$ -angles differed less than 9 degrees to corresponding readings taken in vivo immediately after the osteosynthesis in the included kittens, and more than 19 degrees in the 4 kittens that were excluded.

The preoperative median AV angles of the femoral neck were 24 and 27 degrees, and between matched femurs the median differences in the preoperative AV angle were 0 degrees (Table 2).

### Postoperative course

The kittens tolerated the operation well, and they walked on their right leg from the first postoperative week. The growth plates of the femurs were incompletely closed at 44 weeks and closed at 58 weeks. In most femurs one or more screws loosened slightly resulting in angulation at the osteotomy site of up to 30 degrees, but the osteosynthesis retained most of the *rotational* dislocation in all except 4 kittens, which were

excluded (Table 1). One kitten had to be killed because of an infected neck wound and 1 died under anesthesia, but they were included until 12 weeks postoperatively in the results. At the end of the experiments, the median weight of the remaining 10 animals was 3.6 (2.6–4.5) kg.

The rotational mobility of the hips in the four, 12-week-old, unoperated, additional kittens was about 60 degrees outward and 80 degrees inward. This indicated that a rotational dislocation of about 25 degrees should leave some unrestricted inward and outward range of motion in the hip joint.

### Results

The AV angle of the unoperated left femurs did not change by growth in length (Table 2). The immediate postoperative median torsional difference between matched right and left femurs was  $-20$  ( $-28$  to  $-16$ ) degrees in the outward rotated group and 27 ( $23$ – $41$ ) degrees in the inward rotated group (Table 2). Most of the torsional deformities regressed during the first 12 weeks postoperatively (Table 2). Thus, 44–58 weeks postoperatively, the median torsional difference between matched right and left femurs was  $-1$  ( $-7$  to 1) degrees and 4 ( $-5$  to 8) degrees in the outward and inward rotated groups, respectively.

Forty-four to 58 weeks postoperatively the femurs had grown about 4 cm in length. The operated right femurs were 3.2 ( $-0.5$  to 5) mm longer than the controls.

In all the animals the rotational deformities of the right femurs regressed concurrently with the femoral growth in length (Figure 3).

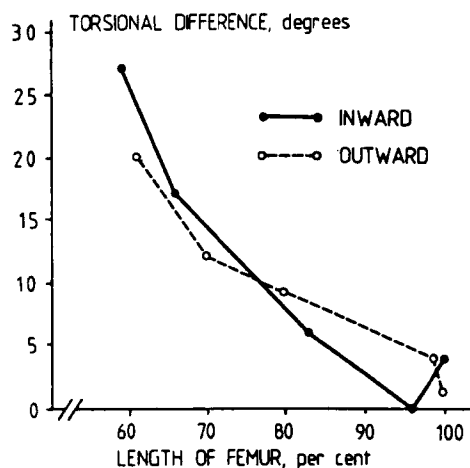


Figure 3. The difference between matched median AV angles (absolute values) decreased with femoral growth in length.

## Discussion

Correction of rotational deformity might be due to failure of the osteosynthesis, to remodelling of the bone, and/or to detorsional physal growth.

When intramedullary nailing was used in dogs, two thirds of rotational osteotomies failed (Schneider 1963). Although some screws loosened in our experiment causing axis deviation of up to 30 degrees, less than 9 degrees of detorsion in the osteotomy was observed, except in the 4 kittens that were excluded (Table 1). Thus, up to one third of the correction of our torsional deformities were caused by postoperative detorsion in the osteotomy.

Because excluded kittens all had *inward* rotational osteotomies, *outward* rotational osteotomies seemed less prone to failure.

A tubular bone like the femur can be remodelled by resorption or by apposition of bone tissue on its endosteal and periosteal surfaces, and within the cortex by haversian remodelling. The latter can be markedly increased under an osteosynthesis plate. If it is applied under very high

tension, this tension is soon markedly reduced by cortical remodelling (Matter et al. 1974). But to our knowledge, no detorsional, cortical remodelling has been reported. On the contrary, it has been shown that luxating the hip joint in puppies induced an increased AV angle of the femoral neck, but no diaphyseal torsional remodelling occurred (Saito et al. 1980). This suggests that the regression of torsional deformities observed here were not due to femoral diaphyseal remodelling.

Our results show that the torsional deformities of the femurs regressed as the bones grew in length (Figure 3), suggesting that the regression took place in the femoral growth plates. Helical growth in length in the distal physis can explain this finding. This contention is supported by the experimental studies of Saito (1977) and Saito et al. (1980).

In children, radiographic data suggest that the proximal femoral growth plate might grow in a dorsal direction, contributing to the physiologic regression of the AV angle of the femoral neck (Morscher 1967). A similar mechanism might also have taken place in our kittens.

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