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Fluoroscopy of rotation in tibial fractures

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Tibial torsion was assessed fluoroscopically in 38 patients with unilateral tibial fractures. Measurements were performed bilaterally after fracture reduction and stabilization. The difference in torsion between the respective tibias of each subject was calculated, and the result was compared with the values obtained from measurements in 100 normal adults with the same fluoroscopic method. A tibial torsion difference exceeding the normal mean ±3 SD was found in 26 percent of the patients. The maximum difference was 49°, as compared with 15° in normal adults. In order to reduce the risk of disabling malrotation, measurement of tibial torsion in the operating room is recommended.

Most reports on series of tibial fractures give no or only sparse information about rotational deformity occurring in the course of treatment (Dehne 1969, Edwards 1965, Ellis 1958, Nicoll 1964, Olerud and Karlström 1972, Sarmiento 1984). The probable reason for this has been the difficulty in detecting such deformities by conventional radiography; and therefore, a rotational deformity may easily be overlooked (Karlström and Olerud 1974). Gershuni et al. (1985) have pointed out that conventional two-dimensional roentgenograms do not disclose the true size of the fracture gap, and have emphasized the importance of the rotational factor. The need of good alignment in regard to rotation ("the third dimension") has been stressed by Connolly (1980).

The aims of this study were to measure the magnitude of the residual malrotation in unilateral tibial fractures after reduction and stabilization and to evaluate the usefulness of a new technique for assessing tibial torsion in clinical practice.

Patients and method

The investigation comprised 38 patients consecutively admitted to our department during 1987 and 1988 for treatment of unilateral tibial fractures (Table 1). All the patients had stable knee joints, and none of them had a history of injury to the contralateral tibia. Treatment followed the guidelines of Karlström and Olerud (1974). Thirteen patients had been treated by open reduction with stabilization by external fixation (6 cases), plating (5 cases), or nailing (2 cases). Twenty-five patients had been treated by closed reduction with stabilization by external fixation (15 cases), a plaster cast (9 cases), or a Scotch cast (1 case).

Tibial torsion was assessed after the fracture had been reduced and stabilized by a conventional technique in a position judged as acceptable by the operating surgeon. In patients with a healed tibial fracture or with a fracture that had been reduced and stabilized at another hospital before admission to our department, a check was made to see that they had not undergone tibial torsion assessment in the previous course of treatment. All the measurements were made in the operating department, and in 5 cases under sterile conditions.

A mobile C-arm fluoroscope, Siemens Siremobil 4N, was used for the measurements. The patient was placed supine on an examination table, which was radiolucent at the ankle level. The knee joint of the leg to be examined was fully extended. The tangent to the posterior contours of the femoral condyles in the lateral view was used as the proximal line of reference. The distal line of reference was equal to the tangent to the inner surface of the medial malleolus in the transverse plane. The repeatability of the method, expressed as the standard error of a single measurement, was found to be 0.74° when applied to normal adults (Clementz 1988a). Patients wearing a plaster cast were examined with equal flexion (approx. 5°) of the knee joints.

The fluoroscopic method for assessment of tibial torsion was used without any difficulty in all the subjects. The lines of reference were easily identified even in patients with a plaster or Scotch cast. In 1 case only,

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Table 1. Material and results obtained from postoperative assessment of tibial torsion

A	B	C	D	E	F	G	H	I	K
CT	2	O	E	L	32/21	11	I	M18	1
	2	O	N	L	25/38	-13	O	M26	3
	2	O	P	L	36/41	-5	O	M24	3
	2	C	PC	R	13/27	-14	I	M47	4
	2	C	E	R	25/12	13	O	M25	1
	2	C	E	L	28/14	14	I	M17	1
	2	C	PC	L	30/14	16	I	M30	2
	2	C	PL	L	23/15	8	I	M23	1
	3	O	N	R	60/40	20	O	M34	1
	3	O	PC	L	23/22	1	O	M31	2
CL	2	O	E	L	28/18	10	I	M47	3
	2	C	PC	L	18/20	2	O	F50	2
	2	C	PC	L	14/13	1	I	M31	1
	2	C	PC	L	17/54	-37	O	M40	4
	2	C	E	R	41/34	7	O	F81	1
	2	C	PC	L	27/22	5	I	M38	1
	4	C	SC	L	10/24	-14	O	M63	1
	4	C	PC	L	12/27	-15	O	M31	1
CC	2	C	E	R	2/18	-16	I	M46	1
	2	C	E	L	31/36	-5	O	F47	1
	2	C	E	L	24/23	1	I	M33	1
	2	C	E	L	18/13	5	I	M62	1
	2	C	E	L	20/15	5	I	M77	1
	3	O	P	L	6/7	-1	O	F54	1
	3	C	E	R	18/25	-7	I	F63	1
	3	C	E	L	42/-7	49	I	M16	1
	3	C	E	R	24/20	4	O	F59	3
	3	C	E	R	20/16	4	O	F38	1
	4	O	P	L	33/27	6	I	M45	1
	4	O	P	L	20/28	-8	O	M46	1
	4	O	P	L	20/30	-10	O	M47	1
	4	O	P	R	33/27	6	O	M45	1
OT	1	O	E	L	35/13	22	I	F37	5
	3	O	E	R	44/33	11	O	M16	1
OC	1	C	E	L	37/10	27	I	M66	1
	2	O	E	L	41/37	4	I	M25	1
	2	C	E	L	33/6	27	I	M18	3
	2	C	E	L	38/27	11	I	M34	2

A Type of fracture: CT closed transverse; CL closed longitudinal; CC closed comminuted; OT open transverse; OC open comminuted.
B Location of fracture: 1 proximal metaphysis; 2 diaphysis; 3 diaphysis + distal metaphysis; 4 diaphysis + distal articular surface (according to Olerud and Karlström 1972).
C Method of reduction: O open; C closed.
D Method of stabilization: E external fixation; N intramedullary nail; P plate; PC plaster cast; SC Scotch cast.
E Fracture side: R right; L left.
F Angle of torsion (degrees): Right tibia/Left tibia.
G Difference in torsion (degrees): + right-sided dominance; - left-sided dominance.
H Direction of residual malrotation: I inward; O outward.
I Sex/Age.
K Status of fracture: 1 fresh traumatic; 2 fresh traumatic, reduced and stabilized in other hospital; 3 healed, admitted for removal of fixation device; 4 healed, admitted for osteotomy; 5 osteotomy in bone lengthening as described by Ilizarov.

the external fixation device had to be slightly adjusted to permit proper exposure of the medial malleolus. Measurement of tibial torsion in both legs was conveniently performed in approximately 10 minutes without causing any problems affecting sterility. It was advantageous to measure the torsion of the uninjured contralateral tibia before the fracture treatment was begun.

Tibial torsion was defined as the angle between the normal to the frontal plane containing the proximal line of reference and the distal line of reference.

Results

In 13 patients treated with open reduction, the difference in torsion between the right and left tibias in the same subject ranged from 22° inward rotation to 20° outward rotation (Table 1).

Among 25 patients treated with closed reduction, inward rotation was found in 15 cases, with a mean torsional difference of 13.7° (SD 12.2°; range 1–49°). Outward rotation was found in 10 cases (mean 10.2°; SD 10.1°; range 1–37°).

With both open and closed reduction, diaphyseal fractures had a lower mean value of the difference in torsion as compared with metaphyseal fractures (Table 2).

In patients with diaphyseal fractures treated with closed reduction, the mean tibial torsion difference was practically the same whether a cast or an external fixation device had been used for stabilization (Table 3). When, however, the fracture was located in the proximal or distal metaphysis, a greater difference was found when an external fixation device had been used than when a cast had been applied.

None of the above differences between groups are significant (Student's *t*-test), but they are reported here to indicate the magnitude of the differences observed.

Table 2. Difference in tibial torsion (degrees) in relation to fracture location and method of reduction

Location of fracture	n	Method of reduction	Difference in torsion		
			Mean	*SD*	Range
Diaphysis (type 2	5 17	Open Closed	9 11	*4* *9*	4–13 1–37
Metaphysis (types 1 + 3 + 4)	8 8	Open Closed	11 15	*7* *15*	1–22 1–49

Table 3. Difference in degrees of tibial torsion in relation to fracture location and method of stabilization. Fractures treated with closed reduction

Location of fracture	n	Method of stabilization	Difference in torsion Mean	SD	Range
Diaphysis (type 2)	7	Cast	12	12	1–37
	10	External fixation	10	7	1–27
Metaphysis (types 1 + 3 + 4)	3	Cast	10	6	1–15
	5	External fixation	18	18	4–49

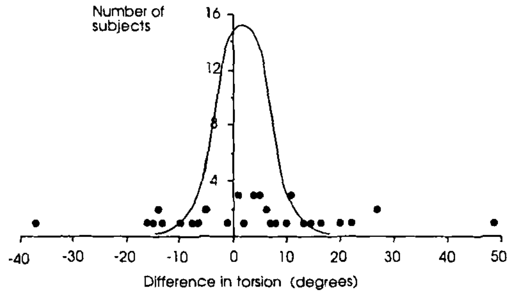

Figure 1. Distribution of the values for difference in torsion between the right and left tibia after fracture. The curve estimates the normal distribution of the corresponding values obtained from 100 normal adults.

Discussion

The difference in torsion between the right and the left tibia in a population of normal subjects was +2.1 ± 5.2° (mean ± SD; the plus sign indicates right-sided dominance) when measured with the technique used in this study (Clementz 1988b). Provided that the values for the difference are normally distributed, the range of –13.5 to +17.7° (mean ± 3 SD) should cover virtually all observations (Figure 1). In the present investigation, 10/38 fractures were reduced with a greater residual rotational deformity. Two of these had open reduction: external fixation for a fracture at the proximal metaphysis and an intramedullary nail for a fracture at the distal metaphysis. The majority of the fractures were equally distributed as regards the tibial level and method of stabilization–external fixation or plaster cast. In the full series, no fracture misangulation was found except in two fractures with 10° of anterior angulation and in two with 5° of valgus deformity.

It is obvious that even when the fractures are treated by experienced orthopedic surgeons, a rotational deformity of 15° or more from the normal means that a difference in torsion between the two tibias can occur in about one fourth of reduced fractures. Most likely, the high percentage of malrotated fractures observed in this series is not exceptional, but will probably be found in any series of fractures treated with a conventional technique.

Several studies have shown that residual malrotation after healing of a tibial fracture may cause symptoms from the knee and ankle, as well as impaired function (Jend et al. 1981, Olerud 1971, Weber 1967, van der Werken and Marti 1983). The correlation between the magnitude of rotational deformity in the tibia and the seriousness of the symptoms caused by it has not yet been established. The symptoms can sometimes necessitate a derotational osteotomy (Debrunner 1967, Olerud 1971, van der Werken and Marti 1983). Debrunner (1967) suggested that such a procedure should be performed in cases of inward rotational deformity of 15° and outward rotational deformity of 20°.

Because the magnitude of torsion in the tibia before the fracture is not known, the reduction of postfracture rotational malalignment must be based on the distribution of the values for torsional difference obtained from measurement in normal subjects. With use of the technique for tibial torsion assessment applied in this study, it can be proposed that closed fractures or open fractures with uncertain points of reference at the fragment ends–with special reference to fractures in the metaphysis–should be reduced so that the right tibia is 2° more outwardly rotated than the left. In this way, malrotation exceeding 15° can be avoided; and according to the normal distribution curve for tibial torsion difference, 75 percent of the fractures will be reduced with a rotational deformity of less than 6°.

Karlström and Olerud (1974) pointed out that no reliable and simple method for measurement of the rotational deformity in the treatment of tibial fractures was available. Methods employing computed tomography have been investigated by Laasonen et al. (1984), who found that with these methods the error could be as great as ±9°. The fluoroscopic technique used in this study proved to fulfill the demands for simplicity and applicability, and it can be recommended for routine use (Clementz 1988a, 1989). It is an advantage that the same equipment that is used for checking the fracture reduction and alignment can also be used by the orthopedic surgeon in the surgical theater to manage the rotational parameter.

Conclusion

In the treatment of tibial fractures, detection and estimation of the magnitude of malrotation is difficult with traditional techniques. Before the quality of reduction of a displaced tibial fracture is accepted, tibial torsion should be assessed. The new fluoroscopic method was found useful in routine treatment of tibial fractures, even in the operating room under sterile conditions.

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