Upsala J Med Sci 94: 67–72, 1989

Radiation Dose in Assessment of Tibial Torsion with a Mobile C-arm Fluoroscope

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ABSTRACT

The absorbed dose to the skin was measured in adult patients undergoing fluoroscopy with a mobile C-arm fluoroscope for determination of tibial torsion. Two methods suitable for routine measurement of tibial torsion were investigated in this respect. The mean absorbed doses for assessment of torsion in one extremity were found to be 5.3 and 5.5 mGy respectively. No scattered radiation to the contralateral foot or symphysis of the patient was recorded. The examiner received no measurable dose on any occasion.

INTRODUCTION

The absorbed dose received by the patient from a radiologic investigation is dependent on technical, physical and procedural factors. Therefore, whenever new examination methods are introduced or already available methods are modified, it is important to evaluate the radiation dose and its distribution.

The radiation risk associated with a particular radiologic investigation cannot be estimated accurately from the risk factors proposed by the International Commission on Radiological Protection (3). However, a risk estimation can be used for a comparison between different methods of examination. It is also possible to weigh the risk against the benefit for a specific group of patients.

The aim of this study was to measure the absorbed dose to the patient and to the examiner when determining tibial torsion according to two methods suitable for routine use.

MATERIAL AND METHODS

Patients and radiologic procedure

The absorbed dose was measured during determination of tibial torsion by two methods:

A. according to Larsson et al. (6) modified by Clementz.

B. according to Clementz (1,2).

The modification of the method of Larsson et al. (6) refers to the positioning of the patient. This was done in order to achieve a reproducible position of the patient.

The initial part of the tibial torsion measurement technique was the same for both methods:

The patient was placed supine on an examination table (Fig. 1). The leg to be examined was fully extended and the foot was supported in the neutral position against a vertical support at the end of the table. The other leg rested with the knee flexed against a side support to allow the x-ray beams to pass uninterrupted through the examined knee. Under fluoroscopic control the examined leg was first rotated so that the posterior contours of the femoral condyles in the lateral view were seen to coincide in the horizontal plane (Fig. 2). The patient remained in this basic position.

The fluoroscope was then moved to the level of the ankle. Applying method A, the tibial torsion value was determined when the C-arm had been rotated until the anterior contours of the trochlea tali were seen to coincide (Fig. 3). In method B, the tangent to the inner surface of the medial malleolus was projected (Fig. 4). The measurement session was completed by again projecting the femoral condyles. This was done under fluoroscopy in order to check that the patient had not moved from the basic position during the measurement procedure. The absorbed doses were recorded for five patients in connection with bilateral measurement of tibial torsion. Measurements were performed with use of both methods at the same measurement session.

Technical equipment

All examinations were carried out with a mobile unit equipped with a 14 cm image intensifier (Philips C-arm BV-21). A fixed focus image intensifier distance of 82 cm was used. The sensitivity of the automatic exposure control was measured to an exposure rate of 54 μR/s at the surface of the input screen. During automatic exposure rate control operation, the tube potential and tube current were adjusted to maintain a constant exposure rate to the input screen. The exposure parameters during fluoroscopy were 45 kV and 1-4 mA.

Absorbed dose measurements

The absorbed dose was measured by means of thermoluminescent lithium fluoride dosemeters (3x3x0.9 mm, TLD-100, Harshaw Chemical Company) and a TLD reader (model 7300B, Teledyne Isotopes). The TLD chips were individually calibrated in 60–Co radiation before and after each measurement. After irradiation they were read at a temperature of 285°C. Prior to this the TLDs had undergone 8 sec of preheating at 135°C and were annealed at 400°C for 30 min. The sensitivity of the TLD chip is strongly energy

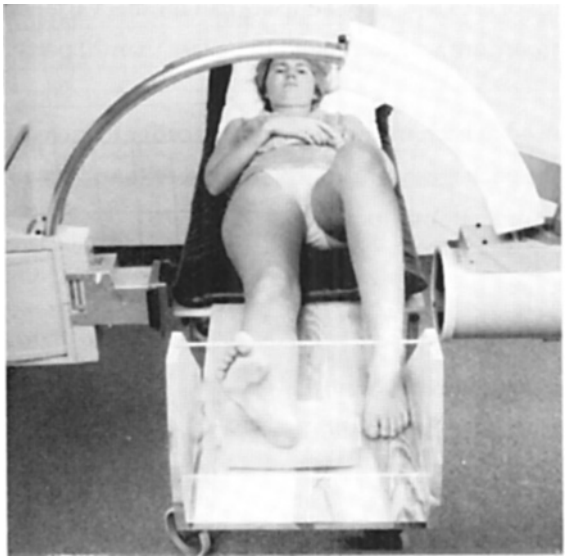

Fig. 1. Patient in the basic position on an examination table, which must be radiolucent at the ankle level.

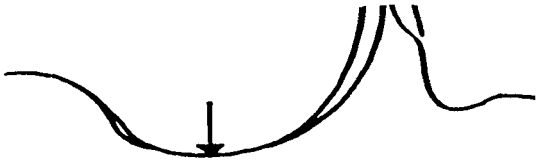

Fig. 2. The dorsal contours of the femoral condyles coincide in the lateral view, defining the proximal line of reference according to both methods.

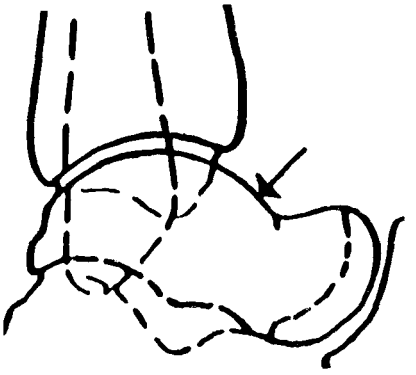

Fig. 3. The anterior contours of the trochlea tali coincide, defining the distal line of reference according to Larsson et al. (6).

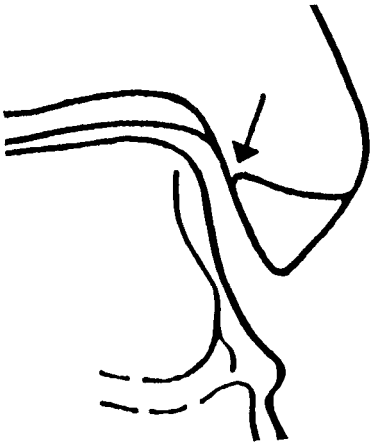

Fig. 4. Projection of the tangent to the inner surface of the medial malleolus, defining the distal line of reference according to Clementz (1,2).

dependent and since there is a variation between beam quality for reference and beam quality for measured radiation, a factor of 0.75 was applied to correct for this variation (9). The total error of the measurement procedure was estimated to be less than 20 percent of the absorbed dose (8).

A package of two TLD chips was used at each measuring point in order to increase the accuracy of the dose measurement. The packages were attached to patients and examiners by means of surgical tape at a number of anatomic locations:

Patient:
1/ lateral femoral condyle
2/ medial femoral condyle
3/ medial malleolus (method B only)
4/ medial side of the talus (method A only)
5/ dorsal side of the foot (nonexamined side)
6/ symphysis

Examiner:
1/ forehead
2/ dorsal side of right hand
3/ dorsal side of left hand
4/ thyroid

For assessment of radiation in each extremity of a single patient a separate set of patient-attached TLDs (Nos. 1-5) was used. The TLD attached to the symphysis of the patient, and the examiner TLDs, remained the same during the complete session of tibial torsion determination in that patient.

RESULTS

The absorbed doses at different locations in patients and examiners are presented in Table 1. A maximum dose to the skin of 3.2 mGy was required to adjust the patient into the basic position for measurement of tibial torsion. With method A the dose to the skin in one tibia varied from 2.4 to 10.0 mGy (mean 5.5). The corresponding values for method B were 2.7 to 8.6 mGy (mean 5.3). No measurable dose was recorded at the skin of the contralateral foot or at the symphysis of the patient with either method. The examiner received no absorbed dose at any time. The effective duration of fluoroscopy was about the same for both methods and in the range of 1.5 to 4 min.

DISCUSSION

Different radiologic techniques have been proposed for assessment of tibial torsion. For none of the methods has the absorbed dose to the patient and to the examiner been reported.

Every intended radiation exposure, including the radiation in diagnostic radiology, must

Table 1. Summary of dosimetry results (mGy)

Dosemeters	Pat 1		Pat 2		Pat 3		Pat 4		Pat 5	
	Dx	Sin	Dx	Sin	Dx	Sin	Dx	Sin	Dx	Sin
Patient:										
Lat.fem.condyle[2]	0[1]	0	0	0	0.5	3.2	0.7	1.7	0	0.9
Med.fem.condyle	0	0	0	0	0	0	0	0	0	0
Talus med.side[3] (method 1 only)	3.4	9.3	2.5	2.4	3.3	10.0	2.9	3.5	8.9	8.5
Med.malleolus[4] (method 2 only)	5.0	6.5	8.6	7.1	3.4	3.5	6.3	6.1	3.7	2.7
Foot dorsal side (nonexamined side)	0	0	0	0	0	0	0	0	0	0
Symphysis	0	0	0	0	0	0	0	0	0	0
Examiner:										
Forehead	0	0	0	0	0	0	0	0	0	0
Dorsum right hand	0	0	0	0	0	0	0	0	0	0
Dorsum left hand	0	0	0	0	0	0	0	0	0	0
Thyroid	0	0	0	0	0	0	0	0	0	0

1) Dose value zero means less than 0.1 mGy.
2) Irradiated area approximately 50 x 100 mm
3) - " - 50 x 70 mm
4) - " - 50 x 40 mm

be motivated by the expected benefits to the patient of the measures necessitating the exposure. The advantage to the patient of early knowledge of the result of tibial fracture reduction is unquestionable, since it might mean that a later correctional osteotomy can be avoided. As a consequence, extensive radiological examinations and an increased radiation dose may be rendered unnecessary.

While it is important that the decision to proceed with examinations or treatment involving exposure to radiations should take into account the dangers of such exposures, it is equally important that these dangers should not be overestimated, since this might lead to the rejection of justified examinations or treatments (3).

Individuals may be exposed mainly from two sources, natural background and medical radiation. The yearly doses from these sources are 1.15 mSv and 0.5 - 1 mSv respectively (7). The radiation generated by indoor radon, which is estimated to be approximately 3 mSv per year, should be added to these figures (7). Only the medical radiation is normally regulated, and its transmission should be kept "as low as reasonably achievable" (3). In fluoroscopy

the absorbed dose to the tissue depends on technical factors, the standard of the equipment and the duration of the fluoroscopy. Although physical methods for dose assessment can be utilized as routine with an accuracy of about 10 percent, it has been found that the patient dose from a specific investigation can vary between different hospitals by a factor of 2 to 10 (4). The exposure rate for fluoroscopy, as measured at the patient entrance, must be kept as low as practicable and should not exceed 50 mGy per min (5). The dose to the skin from a radiological investigation of the knee and ankle has been found to be approximately 4 mGy (10). In this study the size of the absorbed dose in measurement of tibial torsion was about the same, except that a much smaller area was irradiated (Table 1).

In conclusion, we found the procedures for tibial torsion assessment investigated here favorable for routine use both from a methodological and from a radiologic point of view. Somatic and genetic risks to patients are negligible as compared with other clinical risks associated with the treatment of tibial fractures.

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