

## Original Article

# Rotational Malalignment in Osteoarthritic Knees

Abdulla A Ahmed Eyadah, Maria Kondeva Ivanova  
Physical Medicine and Rehabilitation Hospital, Kuwait

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**ABSTRACT**

**Objective:** To study the rotational alignment of lower limbs in patients with osteoarthritis of the knees, measuring two of its components, knee rotation and tibial torsion, by computer tomography.

**Material and Method:** 46 subjects (36 patients with osteoarthritis of the knees and 10 age- and sex-matched asymptomatic volunteers) were included in the study. Cases were required to be "knee pain positive", ascertained using a previously standardized questionnaire and to have at least grade 3 radiographic changes using Kellgren and Lawrence criteria. All 92 limbs were scanned at the level of distal femoral condyle, proximal tibial condyles and ankle joint. Rotation of the knee joint was measured as an angle between the tangent

to the dorsal aspect of femoral condyles (proximal reference line) and the dorsal tangent to the tibial condyles. Tibial torsion was measured as an inclination between the dorsal tangent to the tibial condyles and the tangent to the distal tibia at the level of the medial malleolus.

**Results:** The mean values of the two variables were reduced in patients with osteoarthritis of the knee. The decrease of tibial torsion ( $28.3^\circ \pm 5.1^\circ$ ) in the osteoarthritic patients compared to the control group ( $35.4^\circ \pm 6.2^\circ$ ) showed significance.

**Conclusion:** Rotational malalignment may have some implications in the genesis of osteoarthritis of the rotationally intolerant knee joint.

**KEYWORDS:** computer tomography, osteoarthritis, rotation of the knee, tibial torsion

**INTRODUCTION**

The importance of alignment of the lower limb in osteoarthritis (OA) of the knee is well-known. Reports on the relationship between alignment of the lower limb and osteoarthritis of the knee, as shown by anteroposterior radiographs, have led to surgical treatment by high tibial osteotomy<sup>[1,2]</sup>. Recent attention has been drawn to rotational deformity in the horizontal plane, which can be observed clinically since the foot points inward when the patella is turned forwards. The use of computed tomography has made it possible to accurately measure this torsional deformity.

Torsional abnormalities are considered by some authors to be a possible cause or result of osteoarthritis of the knee<sup>[3]</sup>. In the opinion of some authors, torsional deformities must be corrected at the same time as axial deformities<sup>[4]</sup>. Consequently, it is important to the understanding of the osteoarthritis of the knee, as well as for compound treatment of it, to ascertain whether torsional deformity is present and to measure it.

The aim of the current study was to evaluate the rotational alignment of the leg in patients with osteoarthritis of the knees using computer tomography.

**MATERIAL AND METHOD**

A total of 46 subjects of Kuwaiti origin (36 subjects with OA knees and 10 age- and sex-matched asymptomatic volunteers) were included in the study. They were selected from the out-patients attending the Physical Medicine Department in Al Razi Hospital and Physical Medicine and Rehabilitation Hospital during 1996 – 1998. Knee osteoarthritis was defined on the basis of presence of knee pain, ascertained using a previously standardized questionnaire<sup>[5]</sup>, clinical examination and radiographic changes using Kellgren and Lawrence' criteria<sup>[6,7]</sup>.

None of the subjects included in the study had clinical, laboratory and radiological features to suggest other major rheumatic diseases. Cases were required to be "knee pain positive" and to have at least grade 3 radiographic changes on the scale of 0 to 4. Controls were "knee pain negative" and had normal radiographs.

For all consenting participants, weight-bearing anteroposterior, lateral and sky-line radiographs of the knee joints were taken using standardized techniques. The three compartments of the knee joint were evaluated for joint space narrowing, osteophytosis and sclerosis.

Address correspondence to:

Dr. Maria Kondeva Ivanova, P.O. Box: 31282, 90803 - Sulaibikhat, Kuwait. Tel: (965) 488-9441; e-mail: monika@ncc.moc.kw

For measurement of rotational alignment a Somatom ART (Siemens, Germany) scanner was used. Patients were positioned supine on the sliding table of the whole body scanner, with hip and knee joints extended. Adhesive tape was used to stabilize the feet and thighs and patients were instructed to relax the quadriceps muscle.

All 92 limbs were scanned at the level of distal femoral condyle, slices at 5 mm spacing were taken, at 130 KW, 3 sec scanning time (Fig. 1). The axes for which measurements were taken were: (a) The posterior tangential line of the distal femoral condyles, measuring the widest diameter between the two femoral condyles; (b) the posterior tangential line of proximal tibial condyles measuring the widest diameter between the two tibial condyles; (c) distal axis, which lies between the two points on the posterior border of distal tibia at the level of the most prominent eminencies.

At the level of the knee joint, the upper border of the fibular head provided a reliable landmark. At the level of the ankle, the reference point was the lowest tibial mortice. The distal scans were afforded at the level of the base rather than at the tip of the medial malleolus so that the fibular notch was included.

The measurements for rotational alignment were as follows:

1. Rotation of the knee joint – the angle between (a) and (b)
2. Tibial torsion – the angle between (b) and (c)

The results are presented in form of knees rather than patients. Mean values and standard deviations of the measured angles were calculated for each group. The significance of the differences between the groups was determined by two-tailed student's T-test. Significance was accepted at the  $p < 0.05$  level.

The reproducibility of the measurement technique was determined by having two testers measure the angles at two different times in one week interval from each set of CT films for the patients in the control group without drawing lines or reference points on the films. Between tester differences (the differences between the measurement by the two testers for each patient) were shown as mean value + SD of the differences over all the control subjects. The within tester differences (the differences between two measurements at different time by the same tester for the same person) were shown as the mean value + SD of the differences over all the control subjects.

## RESULTS

The group of patients with osteoarthritis of the knee joint consisted of 36 patients (14 men and 22 women) aged from 36 to 69 years, mean age 52.5

years. A total of 26 patients had moderate (grade 3) and 10 had severe femorotibial osteoarthritis of the knee joints (grade 4).

The control group consisted of four men and six women, aged from 37 to 62 years, mean age 50.1 years.

Tables 1 and 2 present the results of CT scan measurements of tibial torsion and rotation of the knee in the osteoarthritic and control groups with a statistical analysis of the differences. As shown in Table 1, tibial torsion in the control group varied from 17° to 46° with the mean of  $35.4^\circ \pm 6.2^\circ$ . In the osteoarthritic group, the mean value of tibial torsion ( $28.3^\circ \pm 5.1^\circ$ ) was significantly reduced ( $p < 0.05$ ).

Knee torsion showed non-significant reduction in the osteoarthritic group compared to the control group (Table 2).

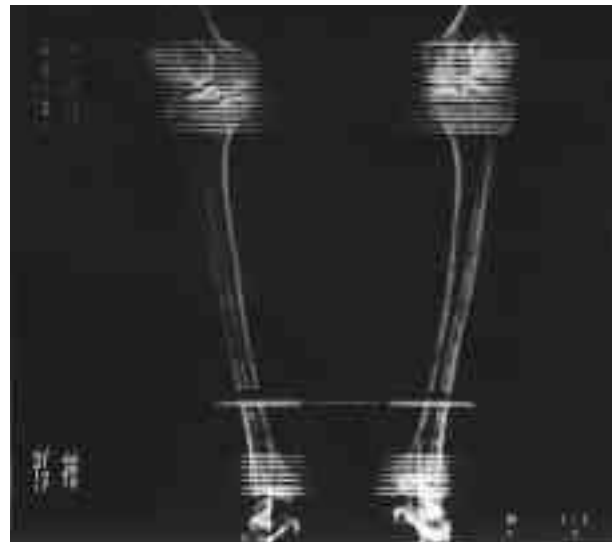


Fig. 1: Computed tomography for measurements of torsional alignment of the leg. Segmental series of 5mm thick tomograms through the femoral and tibial condyles

**Table 1**

Results of measurements of tibial torsion in the control and arthritic group

Knee torsion	Control group (n = 20)	Arthritic group (n = 76)	P value
Mean (SD)	$35.4^\circ \pm 6.2^\circ$	$28.3^\circ \pm 5.1^\circ$	< 0.05
Range	17° to 46°	12° to 64°	

**Table 2**

Results of measurements of knee torsion in the control and arthritic group

Knee torsion	Control group (n = 20)	Arthritic group (n = 76)	P value
Mean (SD)	$3.6^\circ \pm (6.1^\circ)$	$3.2^\circ \pm (6.9^\circ)$	NS
Range	-15° to 13°	-16° to 18°	

The between testers variation of the measured variables was  $0.56 + 2.50$  (range,  $-4^\circ$  to  $4^\circ$ ). The within testers variation of the variables was  $0.43 + 2.30$  (range:  $-3^\circ$  to  $5^\circ$ ).

## DISCUSSION

Tibial torsion is defined as a physiologic twist of the distal versus the proximal articular axis of the tibial bone in the transverse plane<sup>[8]</sup>.

During recent years, methods based on computed tomography (CT scan) have been developed and they enabled the same quality of measurement as that of skeletons<sup>[9]</sup>. It was also found that varus, valgus or flexion deformities of  $20^\circ$  or less exert little effect on the measurement of rotational alignment of the lower limb by CT<sup>[10]</sup>.

Several CT scan methods have been described using different anatomical landmarks to define the transverse axes and, consequently, a great variation has arisen on the values obtained<sup>[9-15]</sup>.

In our study, we used the dorsal tangent to the tibial condyle and distal tibia to determine the proximal and distal reference line for measurement of tibial torsion. Few reports on the measurement of tibial torsion in osteoarthritis of the knee are available in the literature. Ise<sup>[16]</sup> reported an angle of  $17.6^\circ$  in patients with this disease, stating that this angle is reduced in comparison with the normal.

Jagi<sup>[17]</sup> measured  $23.5^\circ$  tibial torsion in normal adults, and observed significant decrease ( $11.3^\circ$ ) in osteoarthritis of the knee, correlating to the radiographic stage of the disease.

The average external tibial torsion in the groups of patients with patellofemoral, medial and lateral osteoarthritis was reduced compared to normal controls in the series of S. Takai<sup>[18]</sup>.

M. Moussa<sup>[19]</sup> found non-significant reduction of tibial torsion in the osteoarthritic group and further non-significant reduction with the progress of the disease, but the group of osteoarthritic knees with quadriceps angle less than  $14^\circ$  demonstrated a significant decrease of tibial torsion.

In the current study, the mean value of tibial torsion in the control group was close to the results reported by Jacob et al on cadaveric tibiae ( $30^\circ$ ), Moussa for Saudi arthritic knees ( $34^\circ \pm 6.7^\circ$ ) and Reikeras et al ( $32.3^\circ \pm 8.5^\circ$  in females and  $35.3 \pm 7.6$  in males). They differ from the values in Jagi and Sasaki series<sup>[17]</sup> and Takai series<sup>[18]</sup>. These differences could be attributed to a number of factors, such as geographical and cultural habits (sitting with crossed legs), biological differences, etc.

Our results substantiate the reports for significant decrease of tibial torsion in patients with osteoarthritis of the knee<sup>[16,17]</sup> and the previously reported non-significant decrease of rotation of the knee in osteoarthritic groups<sup>[18,19]</sup>.

Our between testers and within testers variation analyses showed that this method of measuring tibial torsion and knee torsion has a high degree of precision.

Tibial torsion, knee rotation and femoral torsion are the three components of the rotational alignment of the lower extremities. In osteoarthritis, there is a tendency for compensatory reciprocal balance to occur in the torsional geometries of the lower limb segments with the effect of producing neutral limb alignment. There is a failure of the compensatory mechanism in advanced cases of OA<sup>[19]</sup>. The mechanism could be part of the remodelling response in osteoarthritis.

Rotational malalignment of the femur and tibia may have some implications in the pathogenesis of osteoarthritis at the rotationally intolerant knee joint. However, it is difficult to know whether the alignment predisposed to arthritis; or rotational malalignment can be the result of OA disease. There is probably a complex pattern of interaction between the two.

Life history, obesity, muscle strength and other factors all may influence the alignment of the lower limb.

Post-operative assessment of the torsional alignment of the limb and its segmental variables using CT scan techniques may be helpful in planning the correct rotational position of the implants in total knee arthroplasty.

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