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Tibial torsion: cause or consequence of osteoarthritis?

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Objective: The purpose of this study was to evaluate the relationship between torsional variations of the lower extremity and the development of medial osteoarthritis in the knee.

Methods: Computed tomography measurements of the femoral and tibial torsion were evaluated in 21 lower extremities of 19 patients with primary bilateral gonarthrosis and compared with 14 lower extremities of eight normal individuals.

Results: There was no statistically significant difference between lower extremities with and without gonarthrosis in terms of tibial torsion (26.20°±9.78° and 25.32°±11.50°, respectively), femoral torsion (15.89°±8.63° and 13.91°±7.26°, respectively) and tibiofemoral index (10.30°±13.06° and 11.39°±12.84°, respectively) ($p>0.05$).

Conclusion: We conclude that medial compartment osteoarthritis in the early arthritic period is not always associated with torsional deformities of the lower limb.

Key words: Femoral torsion; gonarthrosis; medial osteoarthritis; tibial torsion.

The etiology of possible primary medial or lateral arthritis of the knee is far from clear. Deformity in the coronal plane is one of the most well-known etiologic factors in medial and lateral compartment osteoarthritis (OA). In addition to the most prominent deformity in the coronal plane, a sagittal plane deformity may also be encountered in an osteoarthritic knee, although not as frequently. Long-term effects of open or closed-wedge osteotomy have been discussed widely in the literature for both deformity types.[1-5] Torsional deformities of the tibia are often associated with advanced OA in the knee. Tibial torsion, as well as being cited as an etiologic factor, is also important in the planning of surgical treatment of the osteoarthritic knee joints.[6,7]

The relationship between medial or lateral OA of the knee and changes in tibial torsion has been indicated in a few reports.[6,8-13] Staheli reported that some torsional deformities, which are common in childhood, persist into adult life to a varying extent.[14] There is some evidence that torsional variations of the lower extremity in some ethnic groups and genders are associated with knee OA.[15] On the other hand, abnormal tibial torsion is more evident in case of advanced OA. We hypothesized that if torsional deformities have an effect on the development of OA, femoral and tibial torsional values would be different between patients with symptoms associated with radiological abnormalities and those without. With this in mind, torsional

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deformities in selected patients could be corrected to prevent OA in the knee.

In the present study, we aimed to determine the relationship between torsional variations of the lower extremity and the development of OA in the knee.

Patients and methods

Twenty-one knees of 19 patients treated with open-wedge valgus tibial osteotomy for primary medial compartment OA between 2002 and 2006 were included in the study. Among them, 17 patients were operated on one side (3 right, 14 left) and two patients on both knees. Patients with secondary OA, a history of previous lower limb fracture or corrective osteotomy, neurological or metabolic disease which may influence lower extremity development and those with a well-developed valgus deformity and diffuse arthritis were excluded from the study. Fourteen knees of eight volunteers with no complaints in the knee who had been referred to our clinic for other reasons were used as the control group. All patients were informed and gave consent for evaluation. The average age at the time of operation was 56.73 (range: 45-66) years in the OA group and 53.37 (range: 48-64) years in the control group. Although the control group was slightly younger than the OA group, it is quite difficult to find individuals without knee complaints in this age group and this difference was not statistically significant ($p>0.05$). In two of the eight volunteers, only one lower limb was used for measurement because of a femoral fracture (one patient) and an acetabular fracture (one patient) on one side. All patients in both groups were women. The selection of only women in the control group was intentional.

Femorotibial mechanical axes and radiographic classification of OA were evaluated on the anteroposterior, standing long-leg radiographs in the OA group. Twelve knees (57.14%) had Grade 2 and 9 knees (42.86%) Grade 1 OA according to Ahlbäck's radiographic classification. There was no marked sagittal plane deformity.

All patients with primary OA had varus deformity and bilateral involvement. In almost all patients one knee predominated in terms of the pain (Figs. 1a and b). Primary indication for osteotomy in these patients was pain which was not relieved sufficiently by analgesics. Other indications for osteotomy were age younger than 70 years, flexion more than 90°, flexion contracture not more than 15° and the absence of marked tibiofemoral laxity in the coronal plane. The most painful side was operated first, followed by the other knee in five bilateral cases (Figs. 1c and d).

Computed tomography (CT) was used to measure femoral and tibial torsion in arthritic and healthy knees.[16] The patient was placed in the supine position, with the hip and knee joints in extension and the foot in the neutral. To measure femoral and tibial torsions, axial scans of the femoral neck, femoral condyles, tibial plateaus and distal tibiofibular joints were obtained. The angle between the axis of the femoral neck and the line joining posterior parts of femoral condyles was defined as 'the femoral anteversion angle' and the angle between the posterior parts of tibial plateaus and the line perpendicular to the distal tibiofibular joint was defined as 'the tibial torsion angle' (Fig. 2).

The mean preoperative torsional value of the osteoarthritic and symptomatic tibias (21 knees) was

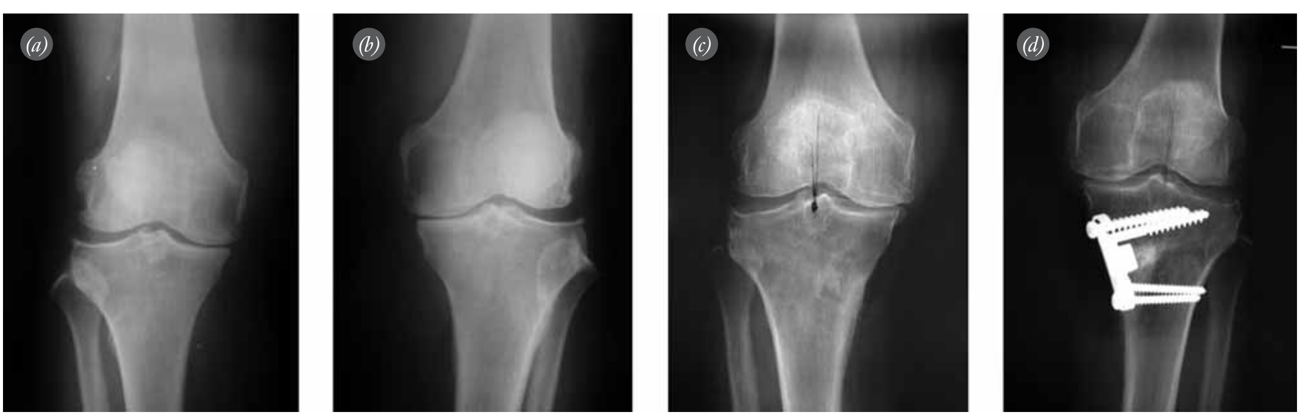

Fig. 1. **(a, b)** Bilateral preoperative, **(c)** postoperative approximately 5th year right knee and **(d)** postoperative 2nd year left knee anteroposterior, standing radiographs of the patient with bilateral osteoarthritis. The implant has been removed on the right side. Both sides show more advanced femorotibial osteoarthritis; however, the joint distance is still not obliterated.

compared with the asymptomatic control group (14 knees). To determine the rotational compensation of the tibia on the femur and vice versa, the 'tibiofemoral index', which considers femoral anteversion and tibial torsion in combination (tibial torsion minus femoral torsion), was calculated for the two groups separately. Results were compared statistically using the unpaired Student's t-test. Significance level was set at $p<0.05$.

Results

No statistically significant difference was identified between the arthritic and symptomatic torsional values in the OA group (26.20°±9.78°) and the control group (25.32°±11.50°) ($p>0.05$). Likewise, no difference was observed between femoral anteversion values of the OA and control groups (15.89°±8.63° and 13.91°±7.26°, respectively) ($p>0.05$). Mean 'tibiofemoral index' values were 10.30°±13.06° in the osteoarthritic lower limb and 11.39°±12.84° in the control group. The difference again was not statistically significant ($p>0.05$). Power analysis calculated with these values was 0.57.

Discussion

Varus deformity of the proximal tibia is often present in OA of the knee and is usually associated with early findings of OA. It has been shown that correcting the frontal plane deformity might provide long-term symptomatic relief in patients with OA. Relief of symptoms depends on changing the load pattern on the sagittal plane of the knee.[17] Moreover, torsional deformities quite frequently accompany frontal plane deformities, particularly in advanced OA.[11-13,18,19] Yagi and Sasaki,[12] and Yagi[13] found a reduction in the external torsion of the tibia in osteoarthritic knees which increases with advancing stages of the disease. The authors concluded that torsional deformity of the leg can influence OA development.

However, it is not clear if OA or torsional deformity develops first. Turner claimed that abnormal torsion causes gait adaptation affecting external loading on the knee joint, which in turn may lead to OA.[11] Contrary to this, in their gait analysis study Wang et al. found that adapted gait mechanisms lower adduction moments on the leg and consequently abnormal loads.[17] There is no

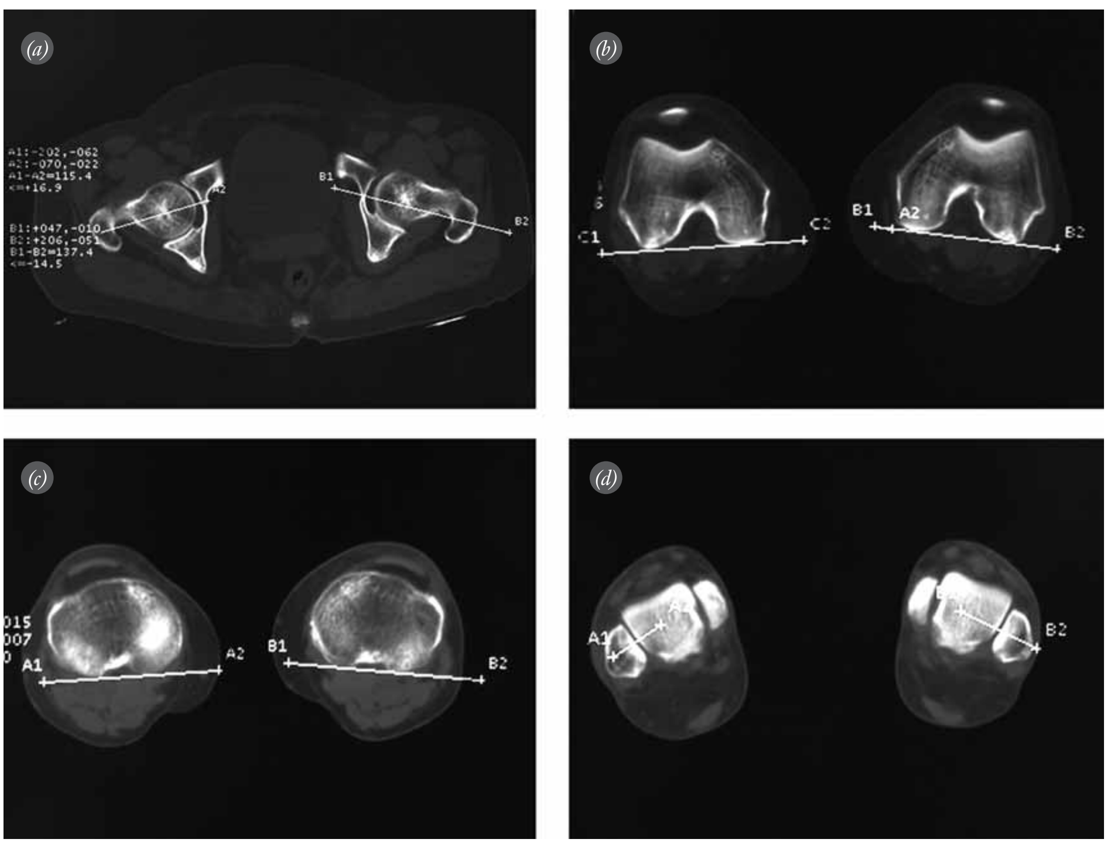

Fig. 2. Computed tomography scans taken at the level of **(a)** the femoral neck, **(b)** the femoral condyles, **(c)** proximal tibia, and **(d)** the distal tibiofibular joint.

clear evidence that axial plane deformity of the tibia, alone or in combination with other factors, is the cause or consequence of OA however. Torsional deformity therefore is one of the controversial subjects concerning the etiology of OA.

Our findings do not support the previously reported results, which indicate a causal relationship between tibial torsion and OA.[11-13] There might be several reasons for this discrepancy. First, different patient characteristics and evaluation methods might affect results. Patients in Turner's series with reduced external torsion or true internal torsion had panarticular OA of the knee.[11] In the current study, patients were solely female and our younger patient group had medial and consequently earlier-stage OA. These results may infer that OA can be an initiator of excessive tibial torsion which becomes exaggerated with advancing OA.

Second, in Turner's series, a tropometer was used, which can only measure 'static' tibial torsion; tibial torsion independent of femoral changes.[11] It was reported that in addition to femoral anteversion, some adaptive 'static' and 'dynamic' changes might develop in the lower limb.[17] These compensatory mechanisms might involve the entire limb and subsequently affect loads exerted on the knee.[7] Wang et al. stated that adaptive mechanisms such as toeing-out during gait can lower the adduction moment due to rotational abnormalities on the lower limb in a substantial number of patients.[17] Therefore, the consideration of tibial torsion alone may neglect 'static' and 'dynamic' adaptive changes and be misleading. Currently, there is no accurate dynamic measuring device available. We agree with Goutallier et al.[20] and Yagi and Sasaki[12] that CT measurements of the femoral and tibial torsions can give more accurate and reliable static results. Therefore, in addition to separate CT measurements of femoral and tibial torsions, the tibiofemoral index was calculated to consider 'dynamic' adaptive changes. However, no significant difference was identified between the OA and control groups ($p>0.05$).

Using the same technique, Goutallier et al.[20] found that the tibiofemoral index was always positive (tibial torsion [mean: 26.51°] lower than femoral torsion [mean: 14.1°]) in patients with medial femorotibial arthritis. Our tibial and femoral torsional values in the images of osteoarthritic and symptomatic legs were consistent with those of the patients with medial arthritis in Goutallier et al.'s series. In their series, tibiofemoral indices of patients with medial and lateral arthritis were compared and the difference was found to be statistically significant. However, although Goutallier et al. found a relation between femoral and tibial torsion and arthritis, their series consisted of patients having opposite compartmental involvement. In our series with patients in earlier stages of medial compartment OA, the difference in the tibiofemoral indices between patients with OA and the control patients were not significant ($p>0.05$). Thus, these findings might infer that advanced medial and lateral OA is related to torsional deformities in the opposite direction. However, they do not prove that OA of the knee follows torsional deformities; on the contrary, the opposite might be true.

We believe that OA in the knee causes deformity in more than one plane. In knees without other abnormalities (e.g. ligamentous injury, trauma), chondral lesions almost always begin with changes in the coronal plane. Internal knee varus movement is dependent on frontal plane moment arm which is a sum of mechanical axis and rotation center of the knee.[6] Krackow et al.[6] found that the greater the mechanical axis change, the lesser the tibial intorsion movement (i.e. the greater foot progression angle). An externally rotated knee joint with shifted bicondylar axis develops a compensation mechanism. During the stance phase, internal tibial torsion moment against the externally rotated knee joint causes increased shear forces on the very medial side of the medial plateau and internal torsion force along the tibia. If the knee ligaments are intact, articular cartilage fibrillation begins at the posteromedial side of the tibial plateau and the medial side of the femoral condyle, always in a linear shape and in the anteroposterior direction. Because this mechanism develops in the late stages of OA and all the patients in this study were in the early stages of OA, any possible relation between OA and torsional abnormality of the lower extremity was not evident. Therefore, a longitudinal study is necessary to follow patients beginning from the mid-term to late stages of OA.

Limitations of this study included a small study group and an inability to evaluate in detail how the rotational variations affect the progression of OA with age or overuse due to its design.

We may speculate that abnormal axial plane loading, related to coronal plane deformities, can initiate OA on the tibia. However, after a critical threshold, abnormal shearing forces on the medial compartment of the tibia also participate in increasing abnormal axial loads, subsequently causing advanced OA and excessive tibial torsion in the late stages of the disease.

In conclusion, our findings showed that medial compartment OA in the early arthritic period is not always associated with torsional deformities of the lower limb.

Conflicts of Interest: No conflicts declared.

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