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Does severe osteoarthritis in knees with varus deformity alter the adductor ratio?

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ABSTRACT

Objective: In our retrospective study, we aimed to investigate the differences between the adductor ratio (AR) in knees with and without osteoarthritis, and its validity in determining the articular level.

Methods: Data from 80 knees of 80 patients were retrospectively evaluated. Anteroposterior weight-bearing knee radiographs of the patients with and without osteoarthritis (40 knees in each group) were obtained. The adductor ratio was determined using the following formula: ATJL/FW (adductor tubercle-joint line distance/femoral width). All radiographs were evaluated at the baseline and at one-month intervals afterwards. Intraobserver reliability of the two measurements was assessed using interclass correlations (ICC). Pearson's correlation test was used to evaluate the correlation between the ATJL and the FW. The differences between the adductor ratios of the two groups were evaluated by the independent samples two-tailed t-test.

Results: Most of the ICC values were well above 0.95, indicating a very high intraobserver reliability. The adductor ratio was significantly greater in Group 2 in comparison to Group 1 (Mean AR in Group 2: 0.522 ± 0.031 and Mean AR in Group 1: 0.502 ± 0.032; $p = 0.005$). There was a significant correlation between the ATJL and FW in the groups when assessed both separately and combined.

Conclusion: In conclusion, we can assert that if the AR is used to determine the articular level in revision arthroplasty cases, it may be sensible to measure the FW intraoperatively rather than measuring it on primary or contralateral radiographs of arthritic patients.

Level of evidence: Level III, Diagnostic study.

Restoration of the joint line (JL) is important for clinical results of primary and revision total knee arthroplasties (TKAs). Proximal displacement of the JL, a common occurrence in revision settings, leads to mid-flexion instability, anterior knee pain, lack of flexion and premature patellar component wear.[1–6]

Determining the articular level using plain radiographs is possible by measuring the absolute distance between a reference bone landmark and the tangent to the JL.[7] The most commonly used bony landmarks are the epicondyles, tip of the fibula head, tibial tubercle and the inferior pole of the patella.[1,3,6,8,9] Recently, the adductor tubercle has been presented as a new bony landmark and the most useful, in determining the articular level in revision knee arthroplasty cases.[7,10]

Absolute distances from anatomical landmarks to the JL have limited utility because of large individual and gender-based variations. Using the ratio of these distances to the transepicondylar femoral width can overcome this problem.[7,9,11,12] The most reliable option, which shows an excellent correlation with the FW, is the adductor ratio (AR).[8,13] Measurements related to the calculation of the AR were made on radiographs of young patient knees without osteoarthritis.[7,13] However, the procedure has been created for revision TKA cases with severe knee arthritis before the index arthroplasty operation. Thus, it is sensible to question the validity of the AR in severe osteoarthritis cases, where loss of bone and cartilage or formation of osteophytes is evident.

In this study, we aimed to investigate the differences between the AR in knees with and without osteoarthritis and its validity in determining the articular level.

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Patients and methods

Data from 80 knees of 80 patients were retrospectively evaluated. The patients were divided into two groups. The first group included 40 knees of 40 patients (4 males [10%], 36 females [90%]; mean age: 73.8 years, range: 57–91 years). Preoperative anteroposterior (AP) weight-bearing radiographs of the patients with Kellgren–Lawrence.[14] Stage 3–4 osteoarthritis with *genu varum* deformity who had undergone TKA were evaluated in this group. In our daily practice, the number of arthritic knees with valgus deformity is very limited. In order to create a homogeneous group to overcome confounding factors, we excluded arthritic knees with valgus deformity. The second group also included 40 knees of 40 patients (16 males [40%], 24 females [60%]; mean age: 33.4 years, range: 22–58 years). AP weight-bearing radiographs of the patients admitted to the outpatient clinic with no knee complaints were evaluated in this group. Radiographs in both groups were obtained from the patients while in standing position and the knee in full extension.

Radiographs demonstrating mild osteoarthritis, previous knee surgery or distorted anatomy due to infection, tumor, inflammatory disease and trauma were excluded.

Measurements were performed directly with a ruler on AP plain radiographs from both groups on the following axes (Fig. 1): (a) FW, the femoral width, described as the line joining the medial and lateral epicondyles at their most prominent points, (b) JL, the joint line, defined as a line tangent to the most distal points of the medial and lateral femoral condyles and (c) the ATJL, described as the perpendicular distance between the adductor tubercle as the distal point on the medial supracondylar slope of the femur and the joint line. In the first group, if large osteophytes were observed medially and/or laterally, possible furthest point of the original boundaries were used for femoral side measurements. The density difference between the femoral cortex and osteophytes was considered the transition zone limit. Fig. 2 shows the boundaries of the medial and/or lateral osteophytes and the possible furthest boundaries of the original femur. All radiographs were evaluated by the same senior surgeon (HB) and the results were recorded. Follow-up results at one-month intervals were also recorded by the same surgeon.

The AR was determined using the following formula for all knees: ATJL/FW.

The sample size was calculated based on the AR of the two groups which was the main endpoint of our study. The mean AR was found to be 0.52 in a recent study.[14] Assuming a 10% variance between the groups, a minimum of 26 patients were needed in each group with an alpha value of 0.05, a beta value of 0.05 and an effect size of 1.04% with a power of 95%. Thus, 40 patients were evaluated for each group. Since both the FW and ATJL were measured as continuous variables, intraobserver reliability of the two measurements was assessed using interclass correlation coefficients (ICCs). For both variables, the ICCs were calculated for the entire dataset and for each group separately. In this case, the difference between the arthritis and non-arthritis groups was investigated by calculating Cronbach's alpha value to determine whether to use the average of the measurements in both groups or not. A Pearson's correlation test was used to evaluate the correlation between the ATJL and FW. Differences between the AR of the two groups were evaluated using the independent samples two-tailed t-test. All analyses were performed with SPSS v.16.0 for Windows® (SPSS Inc.; Chicago, IL, USA).

Since the study was a radiographic study and did not require obtaining additional radiographs, no institutional review board approval was sought.

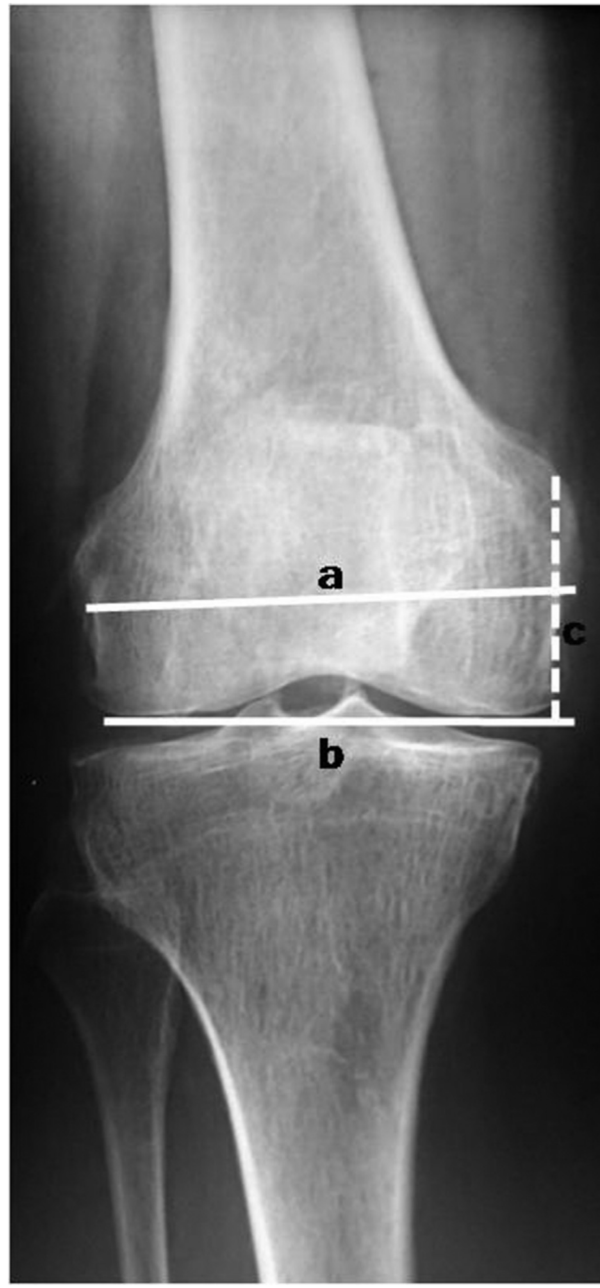


Fig. 1. Axes on anteroposterior plain radiograph of the knee. a: femoral width (FW), b: joint line (JL), c: adductor tubercle-joint line distance (ATJL).

Results

The first group comprised of 10 (25%) left and 30 (75%) right knees with primary osteoarthritis etiology and *genu varum* deformity. The second group comprised of 14 (35%) left and 26 (65%) right non-arthritic knees.

With the exception of ATJL for the second group, all ICC values were well above 0.95, indicating a very high intraobserver reliability. Similarly, the two ATJL measurements had an ICC of 0.881, indicating a high intraobserver reliability. As shown in Table 1, these two measurements are combined in what has become a reliable scale as shown by Cronbach's alpha. In this case, the average of the two measurements taken to examine the difference between the arthritic and non-arthritic groups indicated no problems.

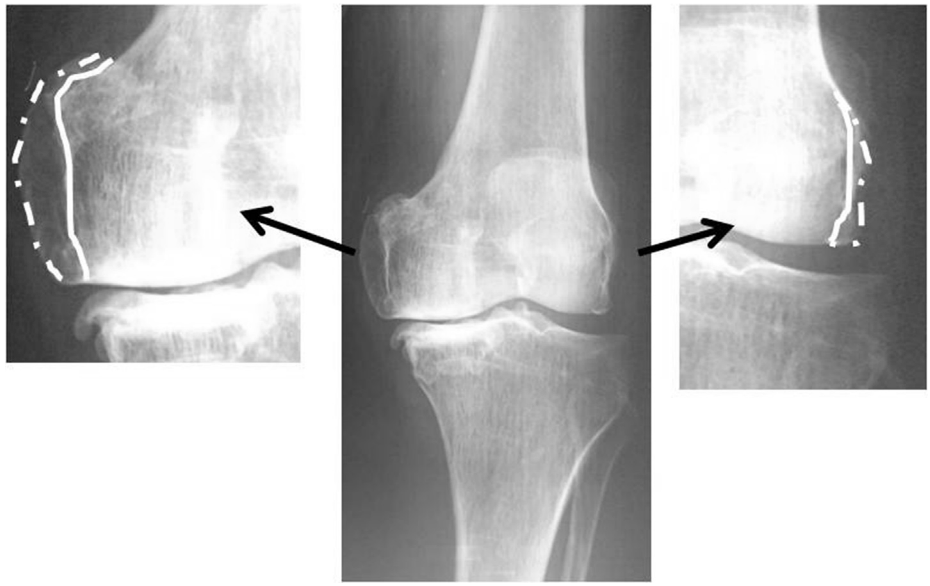


Fig. 2. Boundaries of the medial and lateral osteophytes (dash-dotted line) and the original femur (straight line).

Table 1
Intraobserver reliability results.

	Group 2 (without arthritis)			Group 1 (with arthritis)			Total		
	Cronbach's alpha	ICC	p	Cronbach's alpha	ICC	p	Cronbach's alpha	ICC	p
FW (mm)	0.986	0.972	0.00*	0.997	0.994	0.00*	0.994	0.988	0.00*
ATJL (mm)	0.937	0.881	0.00*	0.956	0.956	0.00*	0.974	0.949	0.00*

* Significance set at $p = 0.001$.
ATJL: adductor tubercle-joint line distance, FW: femoral width, ICC: interclass correlation coefficient.

Group comparisons of the measurements are shown in Table 2. The AR was significantly greater in Group 2 in comparison to Group 1 (Mean AR in Group 2: 0.522 ± 0.031, Mean AR in Group 1: 0.502 ± 0.032; $p = 0.005$). There was a significant correlation between the ATJL and FW in the groups when assessed separately and combined (Table 3). In Table 4, the graph plots the FW values against ATJL values for both groups separately and combined (the lines depict linear regression predictions).

Table 2
Group comparisons of the measurements.

Variable	Group 2 (without arthritis)		Group 1 (with arthritis)		p
	Mean	SD	Mean	SD	
Side	L: 14 (35%), R: 26 (65%)		L: 10 (25%), R: 30 (75%)		0.33
FW (mm) 1st	90.25	9.95	81.4	13.17	0.001*
FW (mm) 2nd	90.18	9.35	81.4	12.84	0.001*
FW (mm) avg.	90.21	9.59	81.4	12.18	0.001*
ATJL (mm) 1st	47.33	6.01	40.65	7.07	0.000*
ATJL (mm) 2nd	46.93	5.6	41.03	6.85	0.001*
ATJL (mm) avg.	47.13	5.63	40.84	6.92	0.001*
ATJL/FW	0.522	0.031	0.502	0.032	0.005*

In the first and second measurements, the p values were calculated and compared using the z-test. For other variables, independent samples two-tailed t-test was applied. The ATJL/FW was calculated using the average of two measurements.
* Significance set at $p = 0.05$.
ATJL: adductor tubercle-joint line distance, FW: femoral width, L: left, R: right, SD: standard deviation.

Table 3
Correlation between the FW and ATJL of the groups separately and combined.

	Pearson's r	p
Combined (Group 1 + Group 2)	0.915	0.000*
Group 2 (without arthritis)	0.861	0.000*
Group 1 (with arthritis)	0.931	0.000*

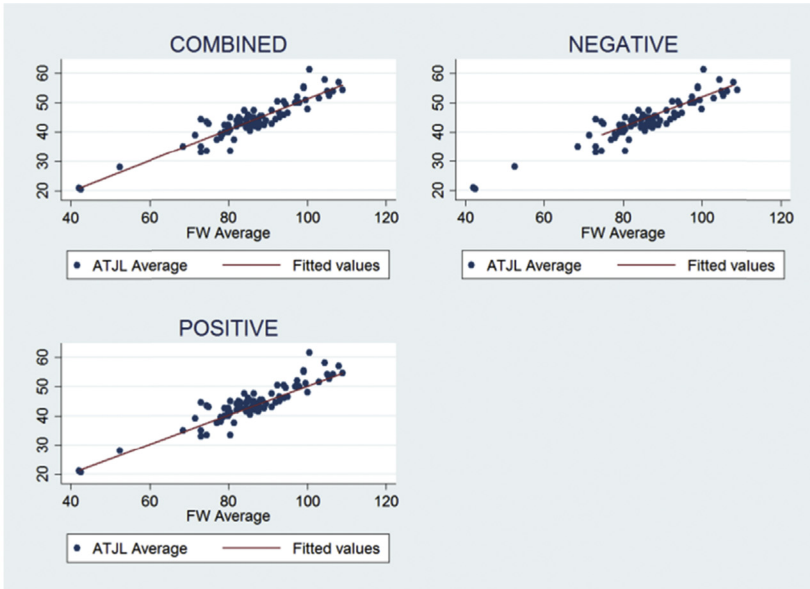
* Significance set at $p < 0,01$.
ATJL: adductor tubercle-joint line distance, FW: femoral width.

Discussion

Our study results revealed that there was a significant correlation between the ATJL and FW in the groups when assessed separately and combined. Also, the AR was significantly greater in the non-arthritic group in comparison to the arthritic group.

Computed tomography (CT), magnetic resonance imaging (MRI) and plain radiographs can be used to determine the position of the JL,[10,15] and reports have shown no difference between CT, MRI and plain radiograph measurements.[10,16,17] In our study, we used plain radiographs for calculating the AR, since it is the most cost-effective and accessible option used in diagnosing knee diseases, preoperative planning of surgical procedures and evaluating postoperative results.[7] Several studies pointed out the requirement of calibrated preoperative radiographs to estimate the AR.[4,7,9,13,18] In our opinion, such requirement is fashionable but not necessary. Today, revision knee arthroplastie scan be performed in smaller centers, which may have no access to such facilities. Conversion of absolute measurements of distance between the anatomical landmarks and

Table 4
FW values against ATJL values for both groups separately and combined (the lines depict linear regression predictions).



NEGATIVE: Group 2 (without arthritis), **POSITIVE:** Group 1 (with arthritis), **COMBINED:** Group 1 + Group 2.

ATJL: *adductor tubercle-joint line distance,* ***FW:*** *femoral width.*

the JL to the AR eliminates the magnification problem and produces a measure independent of size.[11]

On AP radiographs of knees with severe osteoarthritis, the FW may be longer than normal, due to osteophytes in the medial and lateral, and it may be difficult to identify the epicondyles; while the ATJL may be shorter than normal due to the distal femoral cartilage and/or bone loss in the medial compartment of the knees with varus deformity, and the measurements can be affected by the flexion contracture of the knee joint. Even in ignorance of the localized osteophytes on both sides of the femur and using the possible furthest original boundaries for femoral side measurements, advanced osteoarthritis can increase the FW measurement.

The mean AR of 0.522 in our non-arthritic group was similar to the results of two recent studies that reported the ratio as 0.54 and 0.52, respectively.[7,13] In revision arthroplasties, it is possible to plan the articular level on primary radiographs and this information can be used during surgery. If primary radiographs are not available, contralateral knee radiograph scan be helpful.

In revision cases with severe osteoarthritis, intraoperative measurement of the FW may provide more accuracy than that of primary or contralateral knee radiographs. Anatomical changes caused by arthritis and medial and lateral femoral osteophytes will affect the FW. In addition, possible distal femoral bone erosion is another factor that must be considered. The study results showed that the mean AR value was significantly lower in the arthritic group (0.502 vs. 0.522, $p = 0.005$) despite the linear correlation between the ATJL and FW. So, surgeons should remove the medial and lateral femoral osteophytes in surgery settings before measuring the FW in knees with severe osteoarthritis.

Our study had a few limitations. First, patients from a specific geographic region were evaluated. Ethnic and regional differences may have influenced the measurement results and caused drawbacks in comparing the results. Second, flexion contracture, which may affect the measurements to some degree, was not reported. Third, determination of the original femur cortex using the transition zone due to the density difference between the cortex and osteophytes may not necessarily provide accurate results.

Calculation of the AR via the FW and ATJL on AP radiographs can be affected by anatomical changes caused by severe osteoarthritis. Yet, we do not know whether such variation in the AR has clinical significance. Intraoperative measurement of the FW and the calculation of the ATJL may provide more accuracy in determining the articular level in revision knee arthroplasty cases than the measurements on radiographs of knees with severe osteoarthritis. However, this new method has not been scientifically proven.

In conclusion, if the AR is used to determine the articular level in revision arthroplasty cases, it may be sensible to measure the FW intraoperatively rather than measuring it on primary or contralateral radiographs of arthritic patients.

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