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Rotational Landmarks and Sizing of the Distal Femur in Total Knee Arthroplasty

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In 100 knees undergoing a total replacement, the angles between the tangent line of the posterior condylar surfaces, the anteroposterior axis as described by Whiteside, the transepicondylar line, and the trochlear line were measured. Also measured were the sulcus angle, the transepicondylar width, the height of the condyles, and the thickness of the various cuts. Radiologic measurements made were: the mechanical angle, the hip center—femoral shaft angle, the transcondylar angle, and the tibial plateau—tibial shaft angle. The mean values of these measurements were calculated, and comparisons were made according to gender and the mechanical axis using the Student's t test. Correlations between the various measurements were calculated. The transepicondylar axis was found to be a reliable landmark to properly rotate the femoral component, and was easier to locate at surgery than the anteroposterior axis. In trochlear dysplasia and in some valgus knees, relying on the anteroposterior axis can induce an excessive external rotation of the femoral component, and the opposite can happen in some varus knees. The anterior extent of the condyles is highly variable in arthritic knees, and cannot be used to orient the prosthesis. The ratio between the transepicondylar width and the height of the condyles is constant, but some narrow femora could require narrower implants to avoid medial—lateral overhang of the femoral component.

Proper rotational alignment of the femoral component is critical for the outcome of total knee arthroplasty.[1,5,16,23,31,36] The most frequent reasons for reoperation with current condylar prostheses, other than sepsis, relate to the patellofemoral joint.[4,30,35,37,38]

Malrotation of the femoral component on the femur may lead to patellofemoral dislocation or subluxation,[2,3,17,31,34,35] to wear or loosening of the patellar component,[3,15,36,37] or to fractures of the patella.[15,17] Internal rotation of the femoral component on the femur moves the groove portion of the femoral component relatively medially, making it more difficult for the relatively laterally placed patella to be captured by the patellofemoral groove.[1,15,23,27,31,35,36,39] Malrotation of the femoral component may also induce a torsional stress on the tibial component that could lead to wear or loosening.[13]

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The orientation for the femoral component rotation in many instrumentation systems has been set by equal resection of the posterior femoral condyles.[21,27] Insall[23] and others[1,2,3,5,9,10,15,31,36,39,41] recommended that, at times, unequal amounts should be resected off the posterior femoral condyles to obtain ligamentous balance in flexion and to enhance patellar tracking.

Insall[23] and Scuderi and Insall[39] recommended placing a tensor in the knee in flexion and rotating the femoral cutting block so that the posterior edge of the cutting block is parallel to the top of the tibia. This method requires that the tibia be cut first, subsequent to which the distal femur is cut to achieve a correct balance in extension. Next, the femoral cutting block can be properly rotated to obtain a rectangular flexion gap. It may be easier, and more reproducible, to rely on an anatomic landmark to obtain a proper rotational alignment of the femoral component.

Arima et al[2] recently suggested that the anteroposterior (AP) axis of the distal femur was an easy and reliable landmark for rotational alignment of the femoral component, especially in the valgus knee.

For various theoretical reasons that will be briefly discussed, and on the basis of the senior author's clinical experience (JI), the authors thought that the transepicondylar axis was a sound landmark to ensure correct femoral rotational alignment.

Several studies concerning the anatomy and functional axes of the femur have previously been made on normal anatomic specimen femora[2,3,14,26,28,29,40,44] but, to the authors' knowledge, none have been done on arthritic knees at surgery. Those anatomic studies generally ignored the valgus or varus angle of the knee, and were made on bones cleaned from all soft tissues. For those reasons, it seemed useful to perform rotational measurements at surgery, in the course of a total knee replacement. Added to those angular measurements were several radiologic measurements and also some linear measurements related to the sizing of the distal femur.

MATERIALS AND METHODS

A consecutive series of 100 knees undergoing a total knee arthroplasty was studied. The series included 40 bilateral and 60 unilateral total knee arthroplasties, in 80 patients. Thirty-seven were men (46 knees) and 43 were women (54 knees). The mean age of the group was 67 years (range, 36–84 years). Seventy-nine patients had osteoarthritis and 1 had rheumatoid arthritis. Six patients (7 knees) had had a previous high tibial osteotomy, 1 had had a patellectomy, and 1 had had an anterior cruciate ligament replacement.

The mean alignment or mechanical angle (Fig 1), defined as the angle between the mechanical axis of the femur and the mechanical axis of the tibia,[6,9,18,24,31] was 7.5° varus. Eleven knees were in valgus (alignment $< -3°$), and 89 were neutral or in varus (alignment $> -3°$).

Eight of the 11 valgus knees had a lateral retinacular release, whereas only 15 of the 89 neutral or varus knees needed a lateral retinacular release. The tracking of the patella was checked using the no thumb technique, and no maltracking was accepted.

A line was drawn on the distal femoral surface (Fig 2), using a caliper positioned on the most prominent aspect of the lateral and medial epicondyles. This epicondylar line parallels the clinical epicondylar axis, defined by Berger et al,[3] connecting the lateral epicondylar prominence and the most prominent point on the medial epicondyle. Locating those 2 prominences seemed easy at surgery, and there was little variation between the various surgeons involved in the operations about the orientation of this line. On the contrary, the authors were unable to locate the medial sulcus of the medial epicondyle, used by Berger et al[3] on anatomic specimens to define the surgical epicondylar axis.

A second line was drawn on the distal femoral surface, using a guide applied on the posterior condyles. This line paralleled the posterior condylar line. The third line was drawn through the deepest part of the patellar groove anteriorly and the center of the intercondylar notch posteriorly, corresponding to the AP axis, as defined by Arima et al.[2] The angles between those 3 lines were measured using a goniometer. Care was taken to position the goniometer in a plane perpendicular to the mechanical axis of the femur. The angle between the epicondylar line and the

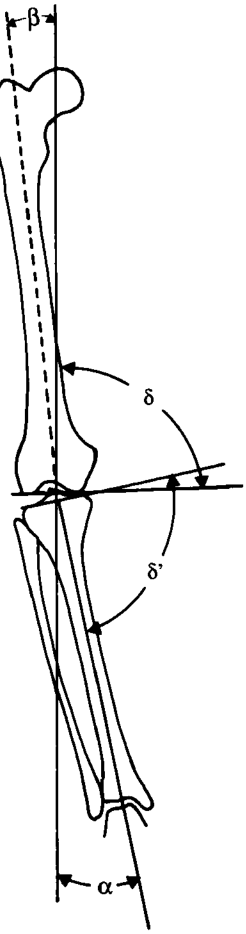

Fig 1. Diagram of the radiologic measurements. α = mechanical axis of the femur—mechanical axis of the tibia angle; β = mechanical axis of the femur—anatomic axis of the femur angle; δ = mechanical axis of the femur—distal condylar line angle; and δ′ = tibial plateau—tibial shaft angle.

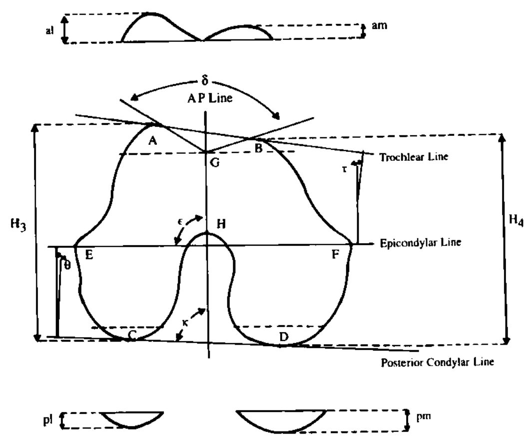

Fig 2. Diagram of the axial view of the distal femur. A and B = the most anterior projections of the lateral and medial femoral condyles; C and D = the most posterior projections of the lateral and medial femoral condyles; E and F = the most prominent points of the lateral and medial epicondyles; G = the deepest part of the trochlar groove; H = the center of the intercondylar notch; AB = trochlear line; EF = epicondylar line; CD = posterior condylar line; GH = anterior—posterior line; AGB = σ = sulcus angle; ε = AP line—epicondylar line angle; κ = AP line—posterior condylar line angle; Θ = epicondylar line—posterior condylar line angle; τ = trochlear line—epicondylar line angle; H3 = height of the lateral condyle; H4 = height of the medial condyle; al = anterior lateral cut; pl = posterior lateral cut; am = anterior medial cut; and pm = posterior medial cut.

posterior condylar line was double checked by measuring the distance between the 2 lines in 2 points 5 cm distant, and using a simple trigonometric formula, as described previously by Mantas et al.[28]

A metallic plate was placed on the trochlea, to figure a line connecting the most anterior projections of the lateral and medial femoral condyles. The angle between this line and the epicondylar line was measured and was called the trochleo-epicondylar angle. The sulcus angle was measured using specially designed metallic templates. The transepicondylar width, defined as the distance from the medial to the lateral epicondyle, and the AP dimension of the lateral and the medial condyles were also recorded, as well as the thickness of the various cuts (anterior lateral, anterior medial, posterior lateral, posterior medial, distal lateral, and distal medial).

The radiologic measurements, performed on standing long leg AP radiographs, included (Fig 1): the alignment of the lower limb; the hip center-femoral shaft angle, defined as the angle between the mechanical and the anatomic axes of the femur; the transcondylar angle, defined as the angle between the tangent line of the condyles and the mechanical axis of the femur; and the tibial plateau-tibial shaft angle, defined as the angle

TABLE 1. Radiologic Parameters According to Gender

Parameter	Group (n = 100)	Male (n = 46)	Female (n = 54)	p
Alignment (mechanical angle)	7.46 [7.42]	9.37 [4.86]	5.83 [8.78]	0.013
Hip center minus femoral shaft angle	6.33 [2.42]	6.63 [3.00]	6.07 [1.78]	0.273
Transcondylar angle	90.64 [2.82]	89.67 [2.97]	91.44 [2.44]	0.002
Tibial plateau minus tibial shaft angle	86.08 [4.04]	85.33 [4.24]	86.72 [3.80]	0.089

Average values are expressed in degrees, with standard deviation in brackets.

between the tangent line of the tibial plateau and the mechanical axis of the tibia.

The mean values of those measurements were calculated, and comparisons were made according to the gender and the alignment, using the Student's t test. Correlation between the various measurements was calculated.

RESULTS

Measurements as Related to Gender

The radiologic, linear, and angular data were compared for men and women. The results are shown in Tables 1 through 4. The data at the 95% confidence level showed significant difference ($p < 0.05$) for the radiologic measurements of the alignment and the transcondylar angle: this reflected the fact that 10 of the 11 valgus knees were in females, and that a valgus knee was related with a larger transcondylar angle.

There were significant differences in the linear parameters of height ($p < 0.001$), transepicondylar width ($p < 0.001$), height of the lateral condyle ($p < 0.001$), and height of the medial condyle ($p < 0.001$). The higher values were in males, as expected.[29,40,44] There was also a significant although small difference between males and females in the ratio between the transepicondylar width and the

TABLE 2. Linear Measurements According to Gender

Parameter	Group (n = 100)	Male (n = 46)	Female (n = 54)	p
Height (inches)	66.2 [4.27]	69.12 [3.50]	63.82 [3.18]	<0.001
Transepicondylar width	90.91 [7.30]	96.93 [5.25]	85.78 [4.24]	<0.001
Lateral condylar height (H3)	69.42 [5.50]	73 [4.74]	66.37 [4.12]	<0.001
Medial condylar height (H4)	68.4 [5.48]	71.72 [4.54]	65.57 [4.57]	<0.001
Transepicondylar width × 2/(H3 + H4)	1.32 [0.06]	1.34 [0.05]	1.30 [0.07]	0.002
Transepicondylar width × 2/(H3 − al + H4 − am)	1.58 [0.08]	1.61 [0.68]	1.55 [0.08]	<0.001

Average values are expressed in millimeters (except for height), with standard deviation in brackets. al = thickness of the anterior lateral cut; am = thickness of the anterior medial cut.

TABLE 3. Angular Measurements According to Gender

Parameter	Group (n = 100)	Male (n = 46)	Female (n = 54)	p
Anteroposterior line minus epicondylar line angle	90.33 [2.44]	91.2 [2.15]	89.59 [2.45]	0.001
Anteroposterior line minus posterior condylar line angle	86.92 [2.71]	88.07 [2.34]	85.94 [2.64]	<0.001
Epicondylar line minus posterior condylar line angle	3.60 [2.02]	3.58 [2.16]	3.62 [1.93]	0.936
Trochleo-epicondylar angle	4.95 [2.15]	4.40 [2.14]	5.38 [2.07]	0.028
Sulcus angle	139.5 [6.96]	139.67 [5.48]	139.42 [5.48]	0.857

Average values are expressed in degrees, with standard deviation in brackets.

mean height of the condyles (p = 0.002), suggesting that females had narrower femurs than males. This difference was even more significant when substracting the anterior extent of the trochlea (anterior cuts) to the height of the condyles (p = 0.0002). When considering this ratio in individual patients, it seemed that the range was relatively wide (1.40–1.89), with again the narrowest femurs in females and the broadest in males. The relatively broadest femora were found in the tallest patients (p = 0.006).

Regarding the rotatory measurements, significant differences between the genders were found for the angles between the AP line and the posterior condylar line (p < 0.001) and between the AP line and the epicondylar line (p = 0.028), but not for the angle between the

TABLE 4. Thickness of the Various Cuts According to Gender

Parameter	Group (n = 100)	Male (n = 46)	Female (n = 54)	p
Anterior lateral	12.94 [2.60]	13.74 [2.76]	12.26 [2.26]	0.005
Anterior medial	9.73 [2.65]	10.63 [2.48]	8.96 [2.56]	0.001
Posterior lateral	7.11 [1.93]	7.54 [1.96]	6.74 [1.84]	0.039
Posterior medial	9.82 [1.86]	10.00 [1.87]	9.67 [1.84]	0.374
Distal lateral	10.09 [2.66]	11.35 [1.83]	9.02 [2.79]	<0.001
Distal medial	9.46 [1.79]	9.56 [2.03]	9.38 [1.58]	0.616
Anterior lateral minus anterior medial	3.21 [2.27]	3.11 [2.32]	3.30 [2.37]	0.683
Posterior lateral minus posterior medial	−2.71 [2.11]	−2.48 [2.17]	−2.93 [2.05]	0.272
Distal lateral minus distal medial	0.62 [2.75]	1.78 [1.90]	−0.36 [2.98]	<0.001

Average values are expressed in millimeters with standard deviation in brackets.

epicondylar line and the posterior condylar line. This suggests that the trochlear groove is angled somewhat externally relative to the epicondylar line in females, and somewhat medially in males. The predominance of females in the valgus group does not entirely account for this difference.

Significant differences between the genders were found for the anterior lateral cut ($p = 0.005$), the anterior medial cut ($p = 0.001$), the posterior lateral cut ($p = 0.0039$), the distal lateral cut ($p < 0.001$), and for the difference between the distal lateral and the distal medial cut ($p < 0.001$). The anterior extent of the trochlea was smaller in females, but this difference can be explained by the smaller size of the femurs. The difference for the posterior lateral and distal lateral cuts can be explained by the predominance of females in the valgus group.

Measurements as Related to Preoperative Deformity

The data for patients with varus and valgus alignment are shown in Tables 5 through 8. There were significant differences for the transcondylar angle ($p = 0.001$), the tibial plateau–tibial shaft angle ($p = 0.001$), and for the hip center-femoral shaft angle ($p = 0.001$). There was a slightly significant difference for the transepicondylar width ($p = 0.048$), reflecting again the female predominance in the valgus group. When the femoral angular measurements were evaluated, there were significant differences for the AP line–epicondylar line angle ($p = 0.047$) and for the AP line–posterior condylar line angle ($p = 0.001$), but not for the epicondylar line–posterior condylar line angle ($p = 0.15$).

The epicondylar line was externally rotated relative to the posterior condylar line by 3.51° ± 2.03° in varus or neutral knees, and by 4.41° ± 1.83° in valgus knees (difference 0.9°). If the rotation of the femoral component was set according to the AP line, the amount of external rotation would be 2.73° ± 2.57° in varus or neutral knees, and 5.91° ± 2.21° in valgus knees (difference 3.18°). There were significant differences for the distal lateral cut ($p < 0.001$), for the difference between the posterior lateral and posterior medial cuts ($p = 0.023$), and for the difference between the anterior lateral and the anterior medial cuts ($p = 0.022$). The posterior lateral cut was 4.36 ± 2.25 mm thinner than the posterior medial cut in valgus knees, and 2.51 ± 2.01 in varus or neutral knees. The trochleo-epicondylar angle had a mean value of 4.95° ± 2.15° and was slightly higher in valgus knees (5.40° ± 2.32°) than in varus or neutral knees (4.89° ± 2.13°) but this difference was not significant.

Similar t tests were done on the paired knees from 40 bilateral total knee replacements, and they revealed no significant difference for any measurement. Wilcoxon

TABLE 5. Radiologic Parameters According to Alignment

Parameter	Varus-Neutral (n = 89)	Valgus (n = 11)	p
Alignment (mechanical angle)	9.51 [4.67]	–9.09 [3.96]	<0.001
Hip center minus femoral shaft angle	6.47 [2.51]	5.18 [0.87]	0.001
Transcondylar angle	90.31 [2.72]	93.27 [2.24]	0.001
Tibial plateau minus tibial shaft angle	85.42 [3.66]	91.45 [2.91]	<0.001

Average values are expressed in degrees, with standard deviation in brackets.

TABLE 6. Linear Measurements According to Alignment

Parameter	Varus-Neutral (n = 89)	Valgus (n = 11)	p
Transepicondylar width	91.31 [7.46]	87.64 [5.06]	0.048
Lateral condylar height (H3)	69.64 [5.46]	67.64 [5.80]	0.298
Medial condylar height (H4)	68.45 [5.45]	68.00 [5.98]	0.816
Transepicondylar width × 2 / (H3 − al + H4 − am)	1.58 [0.081]	1.55 [0.11]	0.373

Average values are expressed in millimeters, with standard deviation in brackets. al = thickness of the anterior lateral cut; am = thickness of the anterior medial cut.

signed ranks tests confirmed those t tests. There was a significant association between a lateral retinacular release (excluding the combined valgus and patellar releases in valgus knees), and a large sulcus angle ($p = 0.029$), a small AP line–posterior condylar line angle ($p = 0.01$), and a small difference in the anterior lateral and anterior medial cuts ($p = 0.02$). The Table 9 summarizes the correlations performed. There was a strong correlation between the alignment and the AP line–posterior condylar line angle ($p = 0.001$), the hip center–femoral shaft angle ($p = 0.018$), the transcondylar angle ($p < 0.001$), and the tibial shaft–tibial plateau angle ($p < 0.001$). There was also a correlation between the alignment and the angle between the AP line and the epicondylar axis, suggesting again that the amount of external rotation induced by the AP line varied more widely from varus knees to valgus knees than the one induced by the epicondylar line. The AP line–epicondylar line angle, the AP line–posterior condylar line angle, and the epicondylar line-posterior condylar line angle were also strongly correlated to each other.

DISCUSSION

The accuracy of the measurements done at surgery, using a caliper, a goniometer, a ruler, and metallic templates is by no doubt

TABLE 7. Angular Measurements According to Alignment

Parameter	Varus-Neutral (n = 89)	Valgus (n = 11)	p
Anteroposterior line epicondylar line angle	90.53 [2.36]	88.73 [2.57]	0.047
Anteroposterior line minus posterior condylar line angle	87.27 [2.57]	84.09 [2.21]	0.001
Epicondylar line minus posterior condylar line angle	3.51 [2.03]	4.41 [1.83]	0.15
Trochleo-epicondylar angle	4.89 [2.13]	5.40 [2.52]	0.524
Sulcus angle	139.67 [7.08]	138.40 [6.06]	0.550

Average values are expressed in degrees, with standard deviation in brackets.

TABLE 8. Thickness of the Various Cuts According to Alignment

Parameter	Varus-Neutral (n = 89)	Valgus (n = 11)	p
Anterior lateral	12.90	13.27	0.576
	[2.67]	[1.95]	
Anterior medial	9.82	9.00	0.219
	[2.72]	[1.90]	
Posterior lateral	7.30	5.54	0.059
	[1.74]	[2.70]	
Posterior medial	9.81	9.91	0.895
	[1.80]	[2.39]	
Distal lateral	10.62	5.82	< 0.001
	[2.08]	[3.03]	
Distal medial	9.48	9.36	0.806
	[1.85]	[1.36]	
Anterior lateral minus	3.08	4.27	0.022
anterior medial	[2.33]	[1.35]	0.023
Posterior lateral minus	−2.51	−4.36	
posterior medial	[2.01]	[2.25]	
Distal lateral minus distal	1.14	−3.54	< 0.001
medial	[2.23]	[3.04]	

Average values are expressed in millimeters, with standard deviation in brackets.

lower than the accuracy of an anatomic specimen study.[2,3,7,14,26,28,29,40,43,44] Moreover, there is no other way to check the reproducibility of the measurements than to ask to various surgeons to perform them on the same patient. Although there was usually an agreement among the observers for the measurements done, this is not a true scientific test. The results of this study should therefore be interpreted cautiously.

The radiologic measurements confirmed the already known fact[7,19,22] that there is a medial slope of the condyles in valgus knees, and a medial slope of the tibial plateau in varus and neutral knees. The hip center-femoral shaft angle was slightly narrower in valgus knees than in varus knees. This difference seemed significant, although this angle can be affected by rotation of the femur.[24] The linear measurements showed that some females have narrower femurs than the average. This confirms the surgical finding that, in some femurs, the femoral component with the adequate AP dimension may be too broad. Additional anatomic work in this field could be useful.

Rotational alignment of the femoral component affects patellar tracking, patellofemoral contact points and pressures, and varus-valgus and rotational alignment of the knee.[1,24] In most normal knees, perpendicular resection of the upper tibial surface removes more bone from the lateral surface of the tibial plateau than from the medial surface, because the normal upper tibia has a 3° varus slope.[8,9,19,23,25,31,32] To obtain a rectangular flexion gap, a larger amount of bone should be resected off the posterior femoral medial condyle than off the posterior lateral condyle.[23,32,39] This argument has been experimentally confirmed by Anouchi et al[1] and Rhoads et al.[36] Those 2 studies showed that patellar tracking after external rotation of the femoral component came closer to reproducing that of the intact knee than any other femoral component position. Internal rotation of the femoral component produced significant changes in the patellar tracking

TABLE 9. Correlation Table

Variable 1	Variable 2	R^2	p
α	β	0.055	0.018
α	δ	0.151	< 0.001
α	δ′	0.334	< 0.001
α	κ	0.109	0.001
α	ε	0.050	0.026
α	υ	0.009	0.356
κ	ε	0.568	< 0.001
κ	υ	0.141	< 0.001
ε	υ	0.064	0.011
pl – pm	κ	0.170	< 0.001
pl – pm	υ	0.195	< 0.001
pl – pm	ε	0.018	0.183
pl – pm	dl – dm	0.099	0.001
Transepicondylar width x′ 2 / (H3 - al + H4 - am)	Height	0.075	0.006

Letters in the variables columns refer to Figures 1 and 2.

pattern that would be expected to increase the incidence of patellar dislocation in prosthetic designs with a shallow trochlear groove, and to increase the incidence of patellar loosening, eccentric wear, and patellar fracture in a prosthesis with a high lateral ridge. Internally rotating the femoral component has also an adverse effect on knee alignment,[3] due to the creation of a trapezoidal flexion gap. Nevertheless, a medial slope of the tibial plateau is not constantly encountered,[32] and it is not clear if the femoral component has to be externally rotated in every total knee replacement,[18] and which amount of external rotation has to be set.

Eckhoff and Coworkers[11,12] have shown that rotational malalignment, with axial malalignment should be considered a mechanical cause of arthrosis. There is a positive correlation between decreased rotation in the femur and increased arthrosis of the medial femoral-tibial articulation[11,33] and between increased femoral anteversion and patellar arthrosis.[11,12,18,20] There is more version in the arthritic knee than in the normal knee.[11] The durability of an arthroplasty for arthrosis may be limited if the intrinsic rotational deformity of the limb is not addressed.[11,13,33,42]

Several methods have been proposed to establish rotational alignment of the femoral component. Insall's technique of the flexion gap consists in rotating the femoral cutting block to create a rectangular flexion gap.[23,39] In this technique, the rotational alignment is dependent on the condition of the medial soft tissues. Arima et al[2] proposed a technique for using the AP axis of the distal femur to establish rotational alignment of the femoral component in the valgus knee. They stated that a line perpendicular to the AP axis consistently was approximated at 4° external rotation relative to the posterior condylar surfaces (3.89° ± 1.77°) and found that the epicondylar axis was more difficult to define, and was not as accurate (4.43° ± 2.81°). The values the authors found in arthritic knees were close to those found by Arima et al, with a larger dispersion: the line perpendicular to the AP axis was at 3.08° ± 2.71° of external rotation relative to the posterior condylar surfaces, the epicondylar line was at 3.60° ± 2.02° external rotation, close to the results of previous anatomic studies,[3,7,28,44] and the AP axis and the epicondylar line were roughly perpendicular to each other (90.33° ± 2.44°).

The authors' opinion in arthritic knees is that the AP axis is sometimes difficult to define, because of trochlear wear or to intercondylar osteophytes. In case of severe trochlear dysplasia relying exclusively on the AP axis could induce excessive external rotation of the femoral component, as illustrated by the wide range (19°) of the angle between the AP line an the posterior condylar line. In some varus knees, relying on the AP line could induce an internal rotation as high as 7°. On the contrary, the range of the angle between the epicondylar line and the posterior condylar line was narrow (8° from −1° to 7°) and relying on the epicondylar line would not induce an internal rotation superior to 1°. The range of the angle between the AP line and the epicondylar axis was 14°.

Kurosawa et al[26] and Elias et al[14] have shown that the posterior femoral condyles closely fit spheric surfaces, of average radius 20 mm with a medial-lateral spacing of 46 mm. In a given knee, the radii can be slightly different for the medial and for the lateral condyle. Elias et al[14] found that the femoral attachments of the medial collateral and posterior cruciate ligaments and of the lateral collateral and anterior cruciate ligaments were in the area of the center of the medial and lateral posterior femoral circles respectively.

Yoshioka et al,[44] in an anatomic specimen study of 32 normal femora, found that the mean transepicondylar line was at a right angle to the mechanical axis of the femur in the frontal plane, and that with the knee flexed to 90°, the transepicondylar line made a right angle to the long axis of the tibia as well. In this study,[43,44] the posterior extent of the condyles referred to the transepicondylar line showed wide variations, the posterior extent of the lateral condyle being smaller than that of the medial condyle. The transcondylar valgus angle, or the distal extent of the condyles to transepicondylar line was also variable, the distal extent of the lateral condyle being again usually smaller than that of the medial condyle.

The perpendicularity of the transepicondylar line to the mechanical axis of the femur, and to the mechanical axis of the tibia with the knee flexed to 90°, makes it a sound landmark for rotational alignment of the femoral component when resecting the proximal tibia at right angles to its mechanical axis. The present study confirms that this landmark can easily be used at surgery, and that it correlates well with the AP axis described by Arima et al.[2] The advantages of the epicondylar line as opposed to the AP axis are that it is less dependent on patellofemoral dysplasia or arthritis, that it is less variable, and that it is never significantly internally rotated relative to the posterior condylar line. It can be used in primary total knee arthroplasty, whatever the alignment, and in revision knee replacement. Double checking the rotation by drawing the AP line and a line parallel to the epicondylar axis should ensure a proper femoral rotational alignment in most total knee replacements.

The low incidence of lateral retinacular releases (15 in 89 total knee replacements) in the group of neutral or varus knees suggests that customizing the amount of external rotation by using those 2 landmarks can be useful even in primary total knee replacement. The high incidence of lateral retinacular release in the valgus group is not significant, because the patellar release is a part of the valgus release routinely performed.

The data presented here underline the importance of measuring the angle between the transepicondylar axis and the posterior condylar line to orient the femoral component, and suggest that some narrow femurs could require narrower femoral implants.

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