

# Low reproducibility of the intra-operative measurement of the transepicondylar axis during total knee replacement

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**Background** The transepicondylar axis is often used for positioning of the femoral component in knee replacement.

**Methods** We studied the reproducibility of the intra-operative palpation of the transepicondylar axis for rotational alignment of the femoral component in 20 total knee replacement (TKR) implantations with a non-image-based navigation system. 2 surgeons defined the transepicondylar axis 3 times each without changing the reference plane.

**Results** The angle between the reference plane and the transepicondylar axis was measured by the navigation system. The mean intra-observer ranges of variation were 5° and 6° for both surgeons, with a maximum of 15°. The mean inter-observer range of variation was 9°, with a maximum of 15°. Variations occurred in either internal or external rotation. Intra-observer agreement was considered good for one surgeon and poor for the other. There was no agreement between the two observers.

**Interpretation** To define the rotational alignment of the femoral component of a TKR according to the intra-operative palpation of the transepicondylar axis may not be as reproducible as expected. However, the exact effect of this variability on the outcome after TKR should be studied.

The transepicondylar axis is an accepted reference for the rotational positioning of the femoral component of a total knee replacement (TKR) (Olcott and Scott 1999). We studied the reproducibility of the intra-operative palpation of the transepicon-

dylar axis for rotational alignment of the femoral component of a TKR with a non-image-based navigation system.

## Patients and methods

We analyzed 20 consecutive TKR implanted for primary osteoarthritis by 2 senior orthopedic surgeons. The mean age of the patients (12 women) was 69 (59–77) years. 14 knees had a varus deformation with a mean mechanical femoro-tibial angle of 10 (5–12)°, and 5 knees a valgus deformation with a mean mechanical femoro-tibial angle of 8 (6–12)°, while 1 knee had no coronal deformation. The SEARCH posterior cruciate preserving TKR (Aesculap, Tuttlingen, FRG) was implanted in all cases (Jenny and Jenny 1998) with a medial transvastus approach using a tourniquet.

We employed the OrthoPilot navigation system (Aesculap, Tuttlingen, FRG), a non-image-based system with intra-operative kinematic and anatomic analyses. The surgical technique has been described elsewhere (Jenny and Boeri 2001a, b, Saragaglia et al. 2001). Briefly, 4 infrared localizers were implanted on screws in the anterior iliac crest, the distal femur and proximal tibia, and strapped on the dorsal part of the foot (Figure). The relative motion of two adjacent localizers was tracked by an infrared camera (Polaris, Northern Digital, Toronto, Canada). The dedicated software calculated the center of rotation of this movement— i.e., the respective centers of rotation of the hip, knee and ankle joints. The 3-D location



The navigation system. 1 = monitor, 2 = infrared camera, 3 = light-emitting diods.

of these centers permitted determination of the mechanical axes of the femur and tibia on both coronal and sagittal planes. Direct palpation by a stylus of the most posterior point of both femoral condyles, in addition to the center of the hip joint, enabled us to determine the reference coronal plane.

The transepicondylar plane was defined by palpation with the stylus of the most prominent points of the medial and lateral epicondyles. The software calculated the angle between the reference and transepicondylar planes; the angle was considered as positive if the transepicondylar axis was externally rotated, and negative if it was internally rotated. 3 palpations of the medial and lateral epicondyles were done during the same procedure by each surgeon, without changing the reference plane, who defined three different transepicondylar axes. The intra-observer variations were studied with by calculating of the intraclass correlation coefficient. The inter-observer variations were studied by comparing the mean value of each case obtained by each surgeon by calculating the intraclass correlation coefficient. All

Angle measured between coronal reference plane and transepicondylar axis (positive if transepicondylar axis is externally rotated, negative if is internally rotated)

Case	First surgeon registration			Second surgeon registration		
	1	2	3	1	2	3
1	0.0	-1.2	-5.2	-5.8	-3.6	-3.6
2	-5.7	5.5	5.2	8.3	4.0	4.6
3	4.0	16.2	9.3	17.7	8.6	17.1
4	7.1	9.4	10.9	8.9	5.0	9.8
5	-5.3	-0.7	-4.4	-7.9	-2.0	-1.8
6	6.7	3.0	4.0	0.2	4.3	1.3
7	4.6	5.4	7.1	10.5	10.9	14.9
8	-3.0	2.1	-4.7	7.8	5.6	3.8
9	-0.1	-2.2	1.5	2.5	4.3	4.7
10	-1.2	0.8	4.7	1.2	-7.2	1.4
11	-5.2	-6.4	-8.8	-2.6	-1.9	-3.5
12	4.8	7.9	5.1	1.0	7.2	5.4
13	-0.1	0.1	3.0	-1.5	4.3	0.7
14	-8.5	-13.4	-9.3	-14.9	-6.8	-12.1
15	-2.7	1.6	-5.6	1.1	1.0	2.1
16	-2.8	-6.3	-14.1	-6.9	-4.6	-4.6
17	10.2	12.1	6.1	7.0	7.9	2.4
18	5.0	10.8	11.1	11.4	-3.9	-2.0
19	7.7	9.7	6.3	5.7	7.9	9.4
20	3.5	6.8	8.2	10.2	14.6	17.1
Mean	1.0	3.1	1.5	2.7	2.9	3.4
SD	5.1	7.0	7.2	7.7	6.0	7.3

statistical analyses were done with a 0.05 level of significance.

## Results (Table)

The mean intra-observer range of variation was 6 (3–12)° for the first surgeon, and 5 (1–15)° for the second. The mean inter-observer range of variation was 9 (4–15)°. Variations occurred in internal or external rotation. The intraclass correlation coefficient for intra-observer variation was good for the first surgeon (0.71, CI 0.54–0.83), but poor for the second (0.50, CI 0.28–0.70). There was no statistically significant correlation between the measurements of the two surgeons (intraclass correlation coefficient 0.18, CI -0.34–0.54). There was no statistically significant difference in the intra- or inter-observer reproducibility by varus or valgus knees.

## Discussion

Rotational alignment of the femoral component of a TKR is essential for optimal ligament balancing (Anouchi et al. 1993, Katz et al. 2001) and patellar tracking (Berger et al. 1998, Akagi et al. 1999). Several methods have been proposed to define the proper alignment during the implantation: the posterior condylar axis (Laskin 1995), the Whiteside line (Whiteside and Arima 1995), the balancing technique (Insall et al. 1985), the tibial axis (Stiehl and Cherveney 1996), and the transepicondylar axis (Berger et al. 1993). The latter is supposed to represent the axis of the knee movement in flexion-extension (Hollister et al. 1993), and may be the most reliable method for determining rotational alignment of the femoral component (Olcott and Scott 2000). However, some authors have found in a cadaver study that it was less predictable than other techniques (Katz et al. 2001), and that the inter-observer variability could reach 23° (Jerosch et al. 2002). The reproducibility of the intra-operative definition of this axis has, to our knowledge, never been analyzed.

Navigation systems can improve reproducible implantation of TKR (Delp et al. 1998). The system we used increases the reproducibility of the implantation of a TKR, as compared to conventional, surgeon-controlled instrumentation (Jenny and Boeri 2001a, b, Saragaglia et al. 2001). However, such systems can also be used to make very precise measurement tools (Delp et al. 1998). Our navigation system has been shown in experiments to have a precision less than one degree in the measurements of this angle (Delp et al. 1998). We therefore measured the angle between one unchanged reference angle (the reference coronal plane) and the variable transepicondylar axis with high precision, and found that the intra-operative palpation of the transepicondylar axis involved a mean of 5° intra- and inter-observer variations, with a maximal variation of 14°. This could be due to poor surgical skill. However, at the time of the study, the surgeons had 13 years (JYJ) and 7 years (CB) of experience in primary and revision total knee replacements. The intra-observer reproducibility of the first surgeon was better than that of the second, but the range of variation was less for the latter. After several years of practice, a highly experienced surgeon may reach

an acceptable reproducibility in the intra-operative definition of the femoral transepicondylar axis. But use of this reference would have a lower and unacceptable reproducibility by less experienced surgeons on a nationwide basis.

More probably, the poor reproducibility may be due to the anatomical shape of both epicondyles and the difficulty in precisely defining the most prominent point because of soft tissue coverage (Berger et al. 1993, Arima et al. 1995, Poilvache et al. 1996, Stiehl and Cherveney 1996).

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