Knee prosthesis evaluation: what radiologist should know

Poster No.: P-0158
Congress: ESSR 2019
Type: Educational Poster
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Keywords: Musculoskeletal joint, Extremities, Musculoskeletal system, Plain radiographic studies, CT, Normal variants, Complications, Prostheses, Outcomes
DOI: 10.26044/essr2019/P-0158

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Learning objectives

To understand the most frequently used radiological measurements after total knee arthroplasty, discuss common pitfalls and their significance to clinical practice.
Background

The knee joint is a complex structure allowing movement in three-dimensions. There are several bony landmarks that are significant for the proper placement of prosthesis components intraoperatively. The most often used technique for total knee arthroplasty is the mechanical alignment: cutting articular surface perpendicular to the mechanical axis. Misalignment in any plane can lead to biomechanical changes: ligamentous imbalance, patellar maltracking, dysfunction of quadriceps muscle, prosthesis failure.

Right after the knee prosthesis operation, the first X-ray is performed to evaluate the initial prosthesis position. Later, for better evaluation, a weight-bearing joint and whole-leg X-rays are performed. In whole-leg X-ray, the main measurements are mechanical and anatomical leg axis, proximal medial tibial and distal lateral femoral angles, femur and tibia valgus/varus, whereas in joint X-ray the main measurements are joint line high and tibial slope. CT brings radiologist an advantage to evaluate components individually and enables to measure the rotation of components. We illustrate the main radiological techniques to obtain these measurements, discuss common pitfalls and their impact on clinical management.
Femoral component varus/valgus alignment

Femoral component varus/valgus alignment is determined by alpha angle (Fig. 1). This is an angle between long axis of femur and a line tangential to articular surface of femoral condyles. It should correspond to the angle between mechanical and anatomical femur axis and be between 3°-7° valgus.

Femoral component flexion/extension alignment

Femoral component flexion/extension alignment is determined by gamma angle (Fig. 2). This is an angle between long axis of femur and the most distal femoral fixation surface.

Posterior condylar offset

The posterior condylar offset is measured by distance between posterior border of femoral condyle and a line extended along posterior femur cortex (Fig. 3). An excessive posterior condylar offset can lead to quadriceps weakness and an increase in posterior cruciate ligament tension.

Posterior condylar offset ratio

The posterior condylar offset ratio is a ratio between posterior condylar offset and a line between anterior border and the tip of condyle's dorsal aspect (Fig. 4). It should be approximately 0.47 postoperatively. Increased condylar posterior offset ratio can lead to a tight flexion gap and restriction of flexion.

Femoral component rotation

Femoral component is evaluated by comparing relationship of prosthesis and femur in axial plane. There are two transepicondylar planes:

- Clinical - between apexes of epicondyles
- Surgical - between lateral epicondylus apex and medial epicondylar sulcus

Surgical transepicondylar axis corresponds to flexion/extension axis. Difference between surgical and clinical axes is 3° internal rotation.

The femoral component rotation is an angle between dorsal condylar surfaces and transepicondylar axis (Fig. 5). It should be 0-1° internal rotation (using surgical axis).

Femorotibial angle

It is an angle between tibial and femoral anatomical axes (Fig. 6). It should be 4°-10° in valgus.
Tibial component varus/valgus alignment

Tibial component varus/valgus alignment is determined by beta angle (Fig. 7). This is an angle between long axis of tibia and a line tangential to articular surface of tibial component. It should be perpendicular to the mechanical axis.

Tibial slope

Tibial slope (sigma angle) is defined as angle in sagittal plane between anatomical axis of tibia and tibial component plane (Fig. 8). Tibial slope stabilizes the knee in flexion. It varies between different endoprosthesis, but it should slope posteriorly approximately 10°. Anterior slope should be avoided as it impedes posterior femoral rollback and leads to restricted knee flexion.

Tibial component rotation

Tibial component rotation is assessed by its relationship to tibial tuberosity (Fig. 9). A method offered by Berger is commonly used. Firstly a geometrical center of tibial plateau is found by drawing a circle at bone borders - the center of this circle matches tibial center. It should be "moved" to the level of tibial tuberosity. Secondly a line perpendicular to the posterior border of tibial component is drawn and "moved" to the level of tibial tuberosity. An angle between this line, geometrical center of tibia and the medial third of tibial tuberosity is measured. Correct component position should be approximately 18± 3° internal rotation. An increase in internal rotation leads to patella maltracking and subluxation.

The level of joint line

The height of the joint line is a distance from the superior edge of tibial tubercle to the tibial component articulating surface (Fig. 10). The level of joint line should not be altered 8 mm or more. A tilted joint line may lead to postoperative pain.

Patellar height

Patellar height is defined as a distance from the inferior edge of patella/patellar component to the proximal edge of the insert (Fig. 11). For good results it should be 10-30 mm.

Patellar tilt

Patellar tilt angle is an angle between a line tangential to anterior border of femoral component and a line connecting medial and lateral edges of patella (Fig. 12). It may imply a tight lateral retinaculum, a component malrotation or valgus alignment of the extensor mechanism.
Fig. 1: Femoral component varus/valgus angle measurement. AB line - femoral anatomical axis; CD line - a line connecting femoral component articular surfaces. An angle between these lines is measured.

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Fig. 2: Femoral component flexion/extension alignment. AB line - femoral anatomical axis; CD line - a line connecting distal femoral fixation surface.

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**Fig. 3:** Posterior condylar offset measurement. AB line - a line extended along posterior femoral cortex. CD line - a line perpendicular to AB to the posterior edge of femoral condyle represents offset.

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**Fig. 4:** Posterior condylar offset ratio. AB line - a line extended along posterior femoral cortex. CD line - posterior condylar offset. CE line - a line connecting posterior condylar edge to anterior border at the same level as posterior condylar offset. A ratio between CD line and CE line is calculated.

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**Fig. 5:** Femoral component rotation measurement. AB line - transepicondylar axis (surgical); CD line - a line between posterior aspects of femoral component.

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Fig. 6: Femorotibial angle measurement. AB line - femoral anatomical axis; CD line - tibial anatomical axis. An angle between these lines is measured.

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**Fig. 7:** Tibial component varus/valgus alignment. AB line - tibial anatomical axis; CD line - a line along tibial component articular surfaces. An angle between these lines is measured.

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Fig. 8: Tibial slope measurement. AB line - tibial anatomical axis; CD line - a line along tibial component articular surfaces. An angle between these lines is measured.

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Fig. 9: Tibial component rotation measurement by Berger. Fig. 1- By drawing a circle tibial center is found. Fig. 2- AB line - a line along the posterior tibial component border. CD line is drawn perpendicular to the AB line. Fig. 3. A medial third of tibial tubercle is found and line GF is drawn to the tibial center. EF line represents tibial component axis (in Fig. 2 CD line), rotation is defined by an angle between GF and EF line.

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**Fig. 10:** The level of joint line measurement. AB line- plane at superior border of tibial tracebule. CD line- joint line height.

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**Fig. 11:** Patellar height measurement.

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**Fig. 12:** Patellar tilt measurement. AB line - a line between anterior borders of femoral component; CD line - a line connecting medial and lateral edges of patella.

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Conclusion

Malposition of knee prosthesis may lead to an early revisional operation. Radiologists should be familiar with radiological measurements.
References

1. Agarwal S, Bansal GJ. Radiology of Orthopedic Implants. Springer; 2018