Medial femorotibial osteoarthritis and genu-valgum: Where is the problem?

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Introduction

Frontal malalignment of the lower limbs has been shown to be closely linked to the onset and progression of knee osteoarthritis. Restoration of a satisfactory alignment after total knee arthroplasty has a positive impact on implant durability and functional result.

An angle measurement commonly used to assess this alignment is the HKA angle (hip-knee-ankle). It is measured on a full length AP radiograph of the lower limbs between the femoral mechanical axis and the tibial mechanical axis.\(^1\)

However, various authors have demonstrated that this measurement, although widely used, could be very inaccurate in case of poor patient positioning during radiographic acquisition. This is especially true when flexion is associated with a rotation of the lower limb.\(^2\)

In this context, the EOS system (EOS imaging, Paris, France) allows, on the basis of a biplane x-ray acquisition, for the construction of a 3D model of the lower limbs in a weight-bearing position. This 3D model provides various clinical parameters, including the HKA angle which, calculated in the knee frontal plane, remains independent of patient positioning during the x-ray acquisition.\(^3\)

Clinical case

We report the case of a 51-year-old patient who came for a radiographic evaluation of knee alignment (figure 1). A standard knee radiograph performed previously showed tibiofemoral osteoarthritis on the right side. This osteoarthritis was predominantly medial, with moderate joint space narrowing but significant osteophytosis.

Clinically, the patient presented irreducible bilateral knee-flexion, which did not allow for the taking of x-rays with the legs fully extended.

A biplane AP and LAT EOS examination of the lower limbs was performed with the EOS system. The frontal EOS radiograph was used to perform a conventional 2D measurement of the HKA angle. The latter was measured between the femoral shaft that connects the centre of the femoral head at point I, and the tibial axis joining the same point C, C being the centre of the talocrural space.\(^4\)

On the other hand, based on the biplane acquisition, a 3D model was generated using dedicated software (sterEOS, EOS imaging) (figure 2). From this modelling, the software application automatically calculated the HKA angle as the angle between the FM and TM axes, projected on the frontal plane of the knee, itself defined as passing through the centre of the medial and lateral condyles and the centre of the femoral head.

The standard 2D measurement found a right valgus of 5.4°, in contradiction with the predominantly medial tibiofemoral knee osteoarthritis. On the contralateral side, a 1.4° varus was measured.

The 3D examination, meanwhile, found a 3.8° varus on the right side, this time in agreement with the observations from the centred x-rays, and a varus of 2.1° on the left side. The flexion of the right and left knees were 33° and 20° respectively. The 3D review also found an increased anteversion of the femoral necks, especially on the right side (28°, against 22° on the left).

Finally, while the 2D examination concluded a leg length discrepancy of 18mm, 3D modelling showed a left leg only 2mm longer than the right leg.

Discussion

The limitations of plane radiology for measuring the frontal alignment of the knees have been widely demonstrated in literature.\(^1\) Routine clinical practice today is based on the optimisation of patient positioning, intended to limit 2D measurement errors. Radiographers generally try to position the patient in such a way that both knees face the x-ray beam, in order to avoid measurement errors. However, in the case of major deformities, this positioning can prove to be a difficult task for the radiographer.

On the case we report here, the patient had bilateral knee flexion and also presented an internal rotation of the knees, especially on the right side, probably favoured by high anteversion of her femoral neck (28°). This created at the right side a “false valgus” (5.4°) on the frontal radiograph, in contradiction with the fact that the tibiofemoral osteoarthritis was predominantly medial.

With the 3D technique, when visualising the modelling in the right knee AP plane, it becomes clear that the deformity is actually a genu-varum (measured at 3.8° with the 3D software) (figure 3). The 2D measurement not only provoked a major measurement error of 9.2° of the HKA angle, but also a reversal in the orientation of the deformity (valgus in 2D, varus in 3D).

On the contralateral side, the knee had less flexion and showed a minor rotation relative to the acquisition plane and the measurement was therefore relatively accurate in 2D (1.4° of varus in 2D against 2.1° varus in 3D).

This case demonstrates the importance of taking into account rotational anomalies of the lower limb when assessing the frontal alignment of the knee. Isolated sagittal deviation, whether in extension or, as is more usual, in flexion, does not lead to errors on the 2D measurement of frontal knee alignment. The combination of rotational deviation of the lower limb and either flexion or extension is a source of errors in 2D measurements. These errors are all the more
important as the flexion and rotation deviation are higher, as can be seen in this case (figure 4), where the 2D measurement error is more important on the right than on the left.

Regarding the assessment of limb length discrepancy, the right limb showed a bigger flexion and therefore seemed 18mm shorter than the left side. In fact, the two lower limbs were almost identical in length.

**Conclusion**

The measurement of the coronal alignment of the knee plays a major role in the planning of total knee arthroplasty or osteotomy realignment. The case we report here illustrates the limitations of conventional 2D measurement. It also shows the interest of 3D modelling performed with the EOS system, especially in the case of complex lower limb deformities. The EOS system allows one to avoid a possible error in surgical planning, which can have serious consequences on the functional level after surgery.

**References**

Figure 3
The EOS model displaying a frontal view of the right knee (A) and a frontal view of the left view (B). The 2D projection error is confirmed. When one limb is in frontal view, the other one is in strong internal rotation and appears to be in valgus.

Figure 4
Axial view ‘from above’. The origin of the 2D projection error is confirmed. There is a combination of a knee flexion together with an internal rotation, particularly on the right side.