CLINICAL REPORT

The EOS imaging system for understanding a patellofemoral disorder following THR

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KEYWORDS
Total hip replacement; Patellofemoral syndrome; Limb-length discrepancy; EOS imaging system

Summary
An aspect of patellofemoral syndrome secondary to total hip replacement (THR) is mainly suggestive of a problem of femoral implant torsion. We here present the first reported case of patellofemoral syndrome secondary to THR relating to limb-length discrepancy, with no abnormality of femoral torsion. The pelvis adapted to the length inequality by axial rotation rather than frontal tilt, and this went undetected on standard X-ray and CT-scan. 3D imaging in upright posture on the EOS system enabled the situation to be clearly described and analyzed, and adapted surgical correction to be indicated.

Introduction
In total hip replacement (THR), function and stability are ensured by complex adjustment of a number of variables, including implant geometry and positioning, lower limb length and soft-part tension [1]. Patellofemoral syndrome may occur following THR [2]. Intuitively, problems of torsion may be suspected, especially in the femoral component; but this interpretation remains controversial and not proven by the literature. We here present a very unusual and exemplary case in which patellofemoral syndrome was related not to any rotational issue but to lower limb-length discrepancy, the relevance of which was demonstrated on the EOS system (Biospacemed, Paris, France).

Lower limb-length discrepancy is generally associated with vertical frontal tilt of the pelvis and hip and knee flexion in the longer limb [3,4]. To the best of our knowledge, there are no literature reports of adaptation by horizontal axial rotation of the pelvis with patellofemoral syndrome related to lower limb-length discrepancy. In the present case, standard X-ray and standard CT-scan (slices taken perpendicular to the examination table) failed to provide a complete account of the posture problem. The EOS system is a very low-dose, high-resolution (0.5 mm resolution; 30,000 gray radiation level, 200 micrograys per acquisition) radiological imaging system allowing simultaneous acquisition in both orthogonal planes in standing position including...
Figure 1  AP pelvic X-ray views (pre-operative, post-operative and after revision), showing changes in hip parameters (FO: femoral offset; BWLA: body weight lever arm; TTCR: distance from trochanteric tip to center of rotation of the hip; HCR: height of the center of rotation).

Clinical case

An active 52-year-old woman had undergone THR in another center, using a cemented Charnley implant with an anterolateral Thomine approach, for arthritis of the right hip. In the immediate post-operative course, she complained of subjective lengthening of the operated limb. In the upright posture and in walking, she showed an unusual posture combining flexion and medial rotation of the hip associated with valgus of the knee. A severe patellofemoral syndrome emerged at 2 months, with a tendency for lateral subluxation of the patella despite normal Merchant patellofemoral X-ray views in dorsal decubitus. On clinical examination in lying posture, right-hip medial and lateral rotation ranges were well-balanced, at 30° each. Preoperatively, the patient had never complained of knee pain, still less of any valgus deformity. The parameters defined by Asayama et al. [10] and Pradhan [11] were calculated from AP pelvic X-ray (Fig. 1). Lower limb CT was also performed to control component version. 2D X-ray assessment [12] found 35 to 50 mm increased femoral offset (direct femoral head center distance to femur axis) and 0 to 14 mm height difference between the tip of the greater trochanter and the rotation center of the femoral head, suggestive of significant lower limb-length discrepancy affecting the right leg [13]. The pelvis, however, showed no tilt on the AP view. The femoral length (center of the head to the top of the intercondylar notch) discrepancy on CT was 1.5 cm: right femur, 41.7 cm; left femur, 40.2 cm. There was no significant difference between left and right limb femoral anteversion on CT (right femur, 7°; left femur, 9°) despite a rotational imbalance with excessive medial rotation in the upright posture. Acetabular anteversion in dorsal decubitus was 28° on CT. The EOS analysis showed it to be in fact 59° in the upright posture. Over and above the variation in anteversion with change in pelvis position from one posture to the other [14,15], this showed adaptive pelvic axial rotation in the upright posture, contributing to right lower limb medial internal rotation. Overall lower limb posture was analyzed in weight-bearing upright posture. The EOS assessment described the lateral subluxation of the patella and the valgus of the knee (Fig. 2).

Revision surgery, performed in the first post-operative year, comprised femoral and acetabular component replacement by an anterior approach (Fig. 1). The objective was to shorten the femur by 10 mm and reproduce femoral and acetabular component anteversion, the implant being stable and without any clinically noticeable conflict. The femoral component was a size-11 cementless Corail implant (Global Ceramconcept) with 45 mm offset, positioned with the same anteversion as the previous implant. A 32/22.2 mm alumina dual mobility cup was employed, to medialize the center of
Table 1  Clinical, radiological, CT and stereo-radiological (EOS™) characteristics according to stage of surgery.

<table>
<thead>
<tr>
<th></th>
<th>Before THR</th>
<th>After first THR</th>
<th>After revision</th>
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<tbody>
<tr>
<td><strong>Clinical</strong></td>
<td></td>
<td>Patellofemoral syndrome</td>
<td>Asymptomatic</td>
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<td></td>
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<td>Flexion contracture of the hip</td>
<td>Normal posture</td>
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<td>Valgus malalignment aspect</td>
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<td><strong>Standard X-ray</strong></td>
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<td>Pelvis horizontal</td>
<td>Pelvis horizontal</td>
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<tr>
<td></td>
<td></td>
<td>Femoral offset: 35 mm</td>
<td>Femoral offset: 39 mm</td>
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<td></td>
<td></td>
<td>Height: 0 mm</td>
<td>Height: 0 mm</td>
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<tr>
<td></td>
<td></td>
<td>HKA = 192°</td>
<td>HKA = 183°</td>
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<tr>
<td><strong>CT</strong></td>
<td></td>
<td>Normal patellofemoral view</td>
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<tr>
<td></td>
<td></td>
<td>Femoral length: 417 mm (Left: 402)</td>
<td>Femoral length: 405 mm (Left: 402)</td>
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<tr>
<td></td>
<td></td>
<td>Femoral anteversion: 7° (Left: 9°)</td>
<td>Femoral anteversion: 8° (Left: 9°)</td>
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<td></td>
<td></td>
<td>Acetabular anteversion: 28° (Left: 38°)</td>
<td>Acetabular anteversion: 30° (Left: 38°)</td>
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<tr>
<td><strong>Stereoradiology (EOS™)</strong></td>
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<td>Acetabular anteversion upright: 59°</td>
<td>Acetabular anteversion upright: 30°</td>
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<td></td>
<td></td>
<td>Axial pelvic rotation: 14° (right anterior iliac)</td>
<td>Axial pelvic rotation: −4° (left anterior iliac)</td>
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<td></td>
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<td>Lateral patellar subluxation</td>
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Discussion

Patients with discrepant femoral length develop compensatory mechanisms in the upright posture and walking. These in turn induce kinematic changes in the lower limbs and pelvis, usually involving pelvic tilt and an attitude of flexion of the hip and knee [16]. The present patient compensated for her lengthened right leg by means of a posture of the knee in flexion associated to medial rotation of the hip, without any pelvic tilt visible on standing AP view. The lateral subluxation of the patella was due to the posture of the knee in flexion and valgus (increased Q angle) and to the medial rotation of the femur [17].

Standard assessment of THR dysfunction comprises AP pelvic X-ray and CT. The surgeon then has to relate the 2D data of standard upright or supine radiology data to the transverse CT slices taken in decubitus. The EOS™ system provides new possibilities, with a direct 3D view in the upright position. In the present case, standard X-ray views suggested discrepancy in lower limb length (distance between hip rotation center and the tip of the greater trochanter; position of the lesser trochanter), but shed no light on the absence of pelvic tilt due to the hip flexion. Moreover, offset and hip-knee angle measurement was affected by the combined malrotation in medial direction and flexion contracture with overestimation of femoral neck offset and an aspect of valgus malalignment at knee level. CT confirmed lower limb-length discrepancy (which could equally have been measured by telemetry in decubitus), and also showed normal and symmetric anteversion of the acetabular and femoral components in decubitus; it did not, however, explain the functional valgus of the knee in the upright position. The EOS™ images confirmed the standard X-ray findings (absence of pelvic tilt, and attitude of flexion of the hip and valgus flexion of the knee) and the CT findings (lower limb-length discrepancy, and anatomic anteversion of the femur and cup). The 3D images completed the analysis, demonstrating axial rotation of the pelvis and patellofemoral subluxation in the upright position. Our analysis of this unusual case was confirmed by the normalization of gait and posture obtained by isolated femoral shortening, in as much as no other parameter was affected by this revision.

Conclusion

Classically, femoral lengthening secondary to THR induces compensation mechanisms including pelvic tilt and hip and knee flexion. The present clinical case shows that other kinds of adaptation are also possible, including rotation of the pelvis, medial flexion rotation of the hip and flexion valgus of the knee, associated with severe patellofemoral syndrome. The EOS™ imaging system, with its low-dose radiation and high definition, provides very clear 3D analysis of overall posture in the upright position.
Conflict of interest statement

None.

References


