MRI: better than CT in the evaluation of patellar extensor apparatus of the knee

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Learning objectives

To describe the protocol used in our institution to study the extensor apparatus of the knee, and its advantages over computed tomography.
Background

The extensor mechanism of the knee is a complex biomechanical apparatus, responsible for the stabilization of the patellofemoral joint and knee extension. Abnormalities in joint congruence and stability lead to pathology and clinical symptoms.

There are five main interlocking factors that affect the stability and congruence of the patellofemoral joint: patellar height; patellar tendon valgus and Q angle; lateral stabilization static mechanism; medial dynamic stabilization structures; and patellar thickness.

Computed tomography (CT) has been used to measure the valgus of the patellar tendon, assess the shape of the trochlea and the degree of patellar tilt and lateral patellar subluxation.

Magnetic resonance imaging (MRI) evaluates the major determinants of patellar stability, the same as with CT, and, in the same study, accesses cartilage damage, soft-tissue and ligament lesions, allowing a much more comprehensive study. No ionizing radiation is used and the study takes only a bit longer than a routine MRI and not much longer than a CT of the knees.

Correct measurements are essential to decide surgical treatment.
Imaging findings OR Procedure Details

In our institution we use a Siemens Magnetom Avanto 1.5 T MRI system, equipped with a dedicated knee coil.

Acquisition starts with the knee placed within a quadrature standard knee coil. The foot is placed 15 degrees in external rotation. Pads are placed under the heel, to raise the foot and place the knee close to zero degrees extension (Fig. 1 on page 7 and Fig. 2 on page 7). Afterwards a routine MRI knee study is performed (sagittal, axial and coronal proton density, fat saturated, images and sagittal T1 and T2* images - Fig. 3 on page 8).

Next, the knee coil is removed and both knees rest on the table (in extension, with the lower limb axis parallel to the longitudinal axis of the table, feet 15 degrees in external rotation - Fig. 4 on page 9).

Fast bilateral axial proton density images are planed (Field of view = 30cm; interval = 5mm; slice thickness = 4mm), the first without quadriceps contraction and the second with quadriceps contraction (from the base of the patella to the tibial tuberosity - Fig. 5 on page 10 and Fig. 6 on page 11).

Total time to perform the study is around 20-25minutes (CT protocol of the extensor apparatus takes around 10minutes).

On the reviewing workstation (software - Osirix MD 7.03 or Syngo VE31H), the following measurements are taken:

- **Tibial tuberosity-trochlear groove distance** (Fig. 7 on page 12) - The distance between two lines, both perpendicular to the posterior intercondylar line, one intersecting the deepest area of the trochlear groove and the second the tip of the tibial tuberosity (which corresponds to the midpoint of the patellar tendon distal insertion). Normal value - < 15mm (a distance between 15 and 20mm is considered borderline; greater than 20mm is abnormal).

- **Patellar tilt, at rest and after quadriceps contraction** (Fig. 8 on page 13 and Fig. 9 on page 14) - The angle between a line joining the extremities of medial and lateral patellar facets and a line tangent to the posterior femoral condyles. Normal value - < 20°.
- **Tibial tuberosity-posterior cruciate ligament distance** *(Fig. 10 on page 15)* - The distance between the center of the patellar tendon insertion and the medial border of the posterior cruciate ligament, using a line parallel to the dorsal tibial condylar line. Normal value - < 24mm.

- **Lateral trochlear inclination** *(Fig. 11 on page 16)* - Angle between a line parallel to lateral trochlear facet and a line connecting the posterior aspects of femoral condyles. Normal value - > 11º.

- **Trochlear facet asymmetry** *(Fig. 12 on page 17)* - The ratio of the length of medial trochlear facet to the length of the lateral facet. Normal value - > 40%.

- **Trochlear depth** *(Fig. 13 on page 18)* - The distance between a line intersecting the anterior aspects of femoral condyles and the deepest point of the sulcus. Normal value - > 3mm.

- **Trochlear groove angle** *(Fig. 14 on page 19)* - The angle between two lines connecting the highest point of femoral condyles to the deepest point of trochlear groove. Normal value - < 145º.

- **Patellotrochlear index** *(Fig. 15 on page 20)* - The ratio between the craniocaudal diameter of the trochlea and patella, on sagittal images. Normal value - > 12%.

- **Insall-Salvati ratio** *(Fig. 16 on page 21)* - The ratio between patellar tendon length and patella length, on sagittal images. Normal value - between 0.8 and 1.2.

**Tips:**

Bilateral axial proton density images are used to determine the tibial tuberosity-trochlear groove distance (TT-TG) and patellar tilt. Unilateral images are used to obtain the remain measurements.

Lateral trochlear inclination, trochlear facet asymmetry, trochlear depth and trochlear groove angle all use the same axial image (the image with the "Roman arch" appearance of the posterior intercondylar fossa, where both epicondyles are seen - Fig. 17 on page 22).

Patellotrochlear index should use the sagittal image with the largest contact between patellar and trochlear cartilage.
Bony landmarks are used to avoid variability related to the cartilage thickness.
**Fig. 1:** Placement of the knee coil and pads under the heel.

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Fig. 2: The knee should be close to extension and the foot 15 degrees in external rotation.

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Fig. 3: Routine knee study in our institution. Above sagittal T1 FSE, PD fat suppressed FSE and T2* GRE images. Bellow axial and coronal PD fat suppressed FSE images.

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Fig. 4: Positioning of lower limbs, with placement of sand bags on both legs, to avoid motion.

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Fig. 5: Bilateral axial proton density images, without quadriceps contraction.

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**Fig. 6:** Bilateral axial proton density images, with quadriceps contraction.

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Fig. 7: Tibial tuberosity-trochlear groove distance.

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**Fig. 8:** Patellar tilt, at rest.

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Fig. 9: Patellar tilt, after quadriceps contraction.

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Fig. 10: Tibial tuberosity-posterior cruciate ligament distance.

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Fig. 11: Lateral trochlear inclination.

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Fig. 12: Trochlear facet asymmetry.

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Fig. 13: Trochlear depth.

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Fig. 14: Trochlear groove angle.

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**Fig. 15:** Patellotrochlear index.

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**Fig. 16:** Insall-Salvati ratio.

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**Fig. 17:** “Roman arch” appearance of the posterior intercondylar fossa.

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Conclusion

Although MRI takes a little more time and is more expensive compared to CT, this protocol allows a reproducible and more informative alternative, when it comes to studying the extensor apparatus and its pathology.
References

- Aarvold A, Pope et al. MRI performed on dedicated knee coils is inaccurate for the measurement of tibial tubercle trochlear groove distance. Skeletal Radiology. 2014;43(3):345-349.
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