MRI-based evaluation of femoral trochlear dysplasia

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Authors: G. Beretis, K. Liberopoulos, A. Demertzis; Athens/GR
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Learning objectives

The aim of this poster is to review the MRI criteria for the diagnosis of femoral trochlear dysplasia, which is a common anatomic variant, correlating with patellofemoral instability and dislocation. To do so we are using clinical cases of patients from our centre, demonstrating the measurements required to establish the diagnosis and the morphologic types of femoral trochlear dysplasia.
The normal trochlea (anterior distal femur) is concave, with medial and lateral facets that articulate with their counterparts on the articular surface of the patella. Femoral trochlear dysplasia is a geometric abnormality of the shape and depth of the trochlear groove, mainly at its cranial part, which makes it insufficient to provide the mechanical restraint capable of avoiding patellar dislocations. It is defined by a sulcus angle of more than 145º, and is believed to be a developmental anomaly, as it appears bilaterally with a high frequency. It is associated with significant disability if left untreated, which makes it important to diagnose and treat early.

Femoral trochlear dysplasia is one of the main predisposing factors contributing to patellofemoral instability (along with patella alta and lateralization of the tibial tuberosity), and a common cause of anterior knee pain in young active adults, especially during flexion activities. It gives patients a sensation of instability and buckling of the legs in daily and sports activities. It has been found that 96% of patients with a history of true patellar dislocation had evidence of trochlear dysplasia. In the long term, it predisposes to the development of osteoarthritis.

Dejour et al. have described four morphologic types of trochlear dysplasia, and introduced a classification system, based on lateral radiographs and CT scans, which is widely used to assess the severity of the condition. The severity of trochlear dysplasia according to this classification is an indication for treatment (trochleoplasty).

The advantages of MRI in assessing femoral trochlear dysplasia include the lack of ionizing radiation, the complete and clear visualisation of the patellofemoral joint, and revealing possible additional injury of the medial patellofemoral ligament, flake fractures, and the tibial tuberosity - trochlear groove distance.
Findings and procedure details

The key to diagnosing femoral trochlear dysplasia is still the lateral radiograph, with the following three signs: The "crossing sign", which represents the point where the trochlea becomes flat. The "double contour sign", which represents the hypoplastic medial facet found posteriorly to the lateral one. The "supratrochlear spur", which is found in the superolateral aspect of the trochlea. Each morphologic type of femoral trochlear dysplasia is characterized by a unique combination of the aforementioned signs. As far as radiographs are concerned, a strict lateral view is necessary in order to avoid misinterpretations.

Femoral trochlear dysplasia can be better assessed by cross-sectional imaging modalities, especially MRI. Several quantitative methods are used to assess trochlear dysplasia with MRI, which have been shown to be accurate and reproducible. These are the following:

**Trochlear depth:** It is assessed by measuring the maximal anteroposterior distance between the medial \((distance \ a)\) and the lateral \((distance \ b)\) femoral condyle and a line paralleling the posterior outlines of the femoral condyles, and the minimal anteroposterior distance between the deepest point of the trochlear groove \((distance \ c)\) and the same line. The formula \(\frac{(a+b)}{2}-c\) is used to calculate the trochlear depth. All measurements are made on an MRI slice 3 cm above the femorotibial joint space on the axial plane. (Fig 1,2).

A trochlear depth less than 3 mm has a 100% sensitivity and 96% specificity of femoral trochlear dysplasia.

**Trochlear facet asymmetry:** It is assessed by measuring the lengths of the medial \((distance \ a)\) and the lateral \((distance \ b)\) facet and calculating their ratio \(\frac{a}{b}\times100\%\). Measurements are made on an MRI slice 3 cm above the femorotibial joint space on the axial plane. (Fig. 3,4).

A ratio less than 40% is indicative of femoral trochlear dysplasia with a 100% sensitivity and 96% specificity.

**Lateral trochlear inclination (LTI):** It is assessed by calculating the angle between a line tangential to the subchondral bone of the lateral trochlear facet and a line tangential to the subchondral bone of the posterior aspect of the femoral condyles \(\text{angle } a\). (Fig. 5,6).
An angle less than 11° is indicative of femoral trochlear dysplasia with a 93% sensitivity and an 87% specificity.

**Lateralization of the patella:** It is assessed by measuring the distance of a line paralleling the lateral margin of the lateral femoral condyle to the most lateral point of the patella (*distance a*), *(Fig. 7).* The measurement is made on a MRI slice showing the maximal extent of the patella on transverse images.

A distance greater than 6 mm has a sensitivity of 75% and a specificity of 83% for femoral trochlear dysplasia.

**Ventral trochlear prominence:** It is assessed by measuring the distance between the line paralleling the ventral cortical surface of the distal femur and the most ventral cartilaginous point of the trochlear floor, on the midsagittal plane (which is defined by the deepest point of the trochlea) *(Fig. 8).*

A distance greater than 8 mm has a 75% sensitivity and 83% specificity for femoral trochlear dysplasia.

**Condyle asymmetry:** It is assessed by measuring the maximal anteroposterior distance of the medial femoral condyle (*distance a*) to the maximal anteroposterior distance of the lateral femoral condyle (*distance b*) and calculating their ratio \(\frac{\text{b}}{\text{a}} \times 100\%\).

A limitation of the measurements is the fact that they cannot be reliably performed in cases of high-grade dysplasia, because of the difficulty to identify anatomical landmarks, e.g. where no trochlear groove is visible. Another limitation is that in some cases the most proximal image to include the entire width of the trochlea, on the axial plane, does not always show the posterior condyles, thus making it hard to define the line tangential to them, which is necessary for the measurements. Moreover, single axial MRI slices are not able to fully describe the morphology of the femoral trochlea, making it necessary to use 3 or more different axial slices.

Dejour’s classification of femoral trochlear dysplasia according to morphologic types:

**Type A:** Normal shape of trochlea with a shallow trochlear groove *(Fig. 9)*

**Type B:** Markedly flattened or even convex trochlea *(Fig. 10)*
**Type C**: Asymmetric trochlear facets, with too high lateral facet and hypoplastic medial facet. (*Fig. 11*)

**Type D**: Type C features plus a vertical link between the medial and lateral facets ("cliff pattern").

Type A is considered low grade dysplasia, whereas types B, C and D are considered high grade dysplasias. Distinguishing between low and high grade dysplasias according to the aforementioned classification system (two-grade system) has been shown to be reliable, which is not the case with the four-grade classification system, as was demonstrated by a recent study.

Despite the fact that quantitative measurements of the femoral trochlea are generally considered reliable, a recent study by Nelitz et al. has concluded that they are of limited value for the assessment of trochlear dysplasia. Furthermore, it showed that none of the measurements could be assigned to Dejour's classification and that measurements could not be reliably performed in high grade dysplasia. However, trochlear depth, facet asymmetry and trochlear inclination could be helpful in distinguishing low-grade from high-grade dysplasia.
Images for this section:

Fig. 1: T2W transverse image showing normal trochlear depth (8 mm)

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Fig. 2: T2W transverse image showing a shallow trochlear groove - trochlear dysplasia (trochlear depth: 2.5 mm)

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Fig. 3: T2W transverse image showing normal trochlear facets (facet length ratio: 65%)

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Fig. 4: T2W transverse image showing trochlear facet asymmetry - trochlear dysplasia (facet length ratio: 35%)

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Fig. 5: T2W transverse image showing a normal femoral trochlea (angle a: 25 degrees)

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**Fig. 6:** T2W transverse image showing lateral trochlear inclination - trochlear dysplasia (angle a: 10 degrees)

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Fig. 7: T2W transverse image showing lateralization of the patella (distance a: 7 mm)

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Fig. 8: T1W sagittal image showing a ventral trochlear prominence (arrow)

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**Fig. 9:** T2W transverse image showing a type A (low grade) femoral trochlear dysplasia - shallow trochlea

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Fig. 10: T2W transeverse image showing a type B (high grade) femoral trochlear dysplasia - flat trochlea

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Fig. 11: T2W transverse image showing a type C (high grade) femoral trochlear dysplasia - asymmetric trochlear facets

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Conclusion

MRI is the imaging modality of choice for assessing femoral trochlear dysplasia and other anatomic factors contributing to patellofemoral instability.
References


