Original Article

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Radiology Section

Role of MRI in Assessment of Risk Factors for Patello Femoral Instability

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ABSTRACT

Introduction: Patellar pathologies are a common cause for anterior knee pain. The Patello-Femoral Joint (PFJ) is a highly complex joint with high biomechanical and functional requirements. Joint geometry plays an important role for stabilization during movements. Developmental and acquired alterations in the geometry of the PFJ are associated with various patellar pathologies.

Aim: To study the diagnostic accuracy of MRI evaluation parameters for trochlear dysplasia in cases of patellar instability. Also, to assess the patellar height ratio using Insail-Salvati index in cases of patellar instability and to assess the Tibial Tubercle to Trochlear Groove distance (TTTG) in cases of patellar instability.

Materials and Methods: MRI Knee scan of 20 study cases of patello- femoral instability and 20 control cases were studied prospectively between December 2015 to 2016. MRI knee was performed using 1.5 T Seimens AVANTO system. The following measurements and criteria were used for evaluation of trochlear dysplasia-

1. Dejour's classification of morphological types of trochlear dysplasia:

2. Lateral trochlear inclination angle.

3. Trochlear facet asymmetry ratio

4. Trochlear depth.

Patella Alta was assessed using InsalL-Salvati index and TTTG distance was calculated on axial section Images.

Results: The mean age group was ~29 years and median age group was 27 years.

Morphology of trochlear dysplasia in study group: Type A -10 cases (50%); Type B- 1 case; Type C- 9 cases (45%); Type D- Nil. The mean lateral inclination angle showed 95% sensitivity and 100% specificity for trochlear dysplasia. The mean trochlear facet ratio showed 75% sensitivity and 100% specificity. The mean trochlear depth showed 90% sensitivity and 100% specificity.

Patella alta was seen in 18 out of 20 study cases.The mean tibial tuberosity to trochlear distance was ~19.28mm in study group and ~ 7.2mm in control group.

Conclusion: MRI plays an important role in assessment of risk factors for patello-femoral instability. Standardized MR parameters helps in accurate diagnosis of trochlear dysplasia, lateralization of tibial tuberosity and patella alta and helps in optimal treatment planning.

Keywords: Patella alta, Trochlear depth, Trochlear dysplasia

INTRODUCTION

The PFJ is a highly complex structure with high biomechanical and functional requirements for the day to day functioning [1]. Normal function of the joint is maintained by the extensor muscles which form the active stabilizers and by the bones and ligaments which are the passive stabilizers. Joint geometry plays an important role for stabilization during movements. Developmental and acquired alterations in the geometry of the PFJ are associated with various patellar pathologies [2].

Patellar pathologies are a common cause for anterior knee pain in adolescent and young adults [3].

Patello-femoral instability is defined as an abnormal lateral translation of patella during flexion of the knee with or without patellar dislocation [3]. Chronic patella-femoral instability and recurrent dislocation of patella may contribute to chondromalacia patella and severe arthritis if left untreated [2]. The three most important risk factors for patella-femoral instability include-patella alta (high riding patella), trochlear dysplasia and lateralization of tibial tuberosity [4]. Trochlear dysplasia is defined as flattening of the trochlear surface that causes lateral patellar dislocation in flexion [5].

MRI Imaging is now a well-established technique replacing diagnostic arthroscopy as the primary non-invasive imaging modality for patella-femoral instability. MRI gives accurate and reproducible measurements for assessment of trochlear dysplasia [3].

MRI helps in quantification and characterization of these anatomic risk factors and helps in deciding the orthopaedic management [6].

MATERIALS AND METHODS

A prospective case control study was conducted between the period of December 2015 to December 2016 in Department of Radiodiagnosis at Bangalore Medical College and Research Institute, Bengaluru, India. A total of 20 patients in the age group of 15-45 years who were referred to our Department with clinical diagnosis of patello-femoral instability were selected and included in case group using random sampling. Corresponding age and sex matched control cases were selected with no signs and symptoms of patello-femoral instability. All patients with traumatic patellar dislocation, contraindications to use of MRI, and history of previous knee surgery were excluded. Informed written consent was obtained from all cases and controls. Ethical Committee Clearance was obtained for the study.

MRI knee was performed using 1.5 T Seimens AVANTO system using extremity coil, FOV of 14 to 16 cm and a 256x256 matrix. Sequences taken included T2 Coronal, Sagittal, T2FS axial, PDFS - Coronal, Sagittal, T1 sagittal and gradient sequences.

Image Interpretation

The following measurements and criteria were used for evaluation of trochlear dysplasia.

1. Dejour's Classification: It was used for classifying the morphology of trochlear dysplasia [4,7].

Type A-Normal trochlear shape preserved but it appears shallow.

Type B- Flattened or convex shape of trochlear surface.

Type C- Trochlear facet asymmetry and hypoplastic medial facet.

Type D- Cases with type C morphology with ventral prominence in supra trochlear region [7].

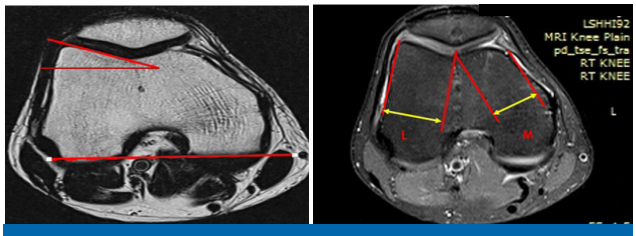
2. Lateral Trochlear Inclination: The superior most section from axial data set showing trochlear cartilage was selected. Inclination Angle was measured between a line through the lateral trochlear facet along the sub chondral bone and a tangential line running along the posterior surface of femoral condyles. An inclination angle of ≤11degrees was taken as cut off for trochlear dysplasia [8] [Table/Fig-1].

3.Trochlear Facet Asymmetry Ratio: Ratio of medial trochlear facet length to lateral trochlear facet length was calculated ~3cm above the tibio femoral cleft on an axial MR image. A trochlear facet ratio of <40% was taken as cut off for trochlear dysplasia [2] [Table/Fig-2].

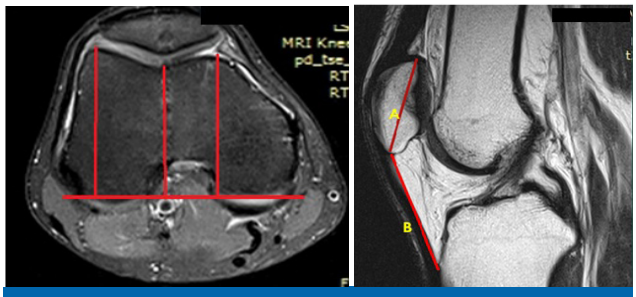
4. Trochlear Depth: On an axial section image ~3cm above the tibio-femoral cleft, a line was drawn parallel to posterior aspect of femoral condyles as a reference line (D). Largest AP dimension of medial (A) and lateral trochlear facets (C) and the deepest point of sulcus (B) were drawn perpendicular to line D.

Trochlear depth was calculated using formula - (A+C/2)–B. Trochlear Depth <3mm was taken as cut off for trochlear dysplasia [2] [Table/Fig-3].

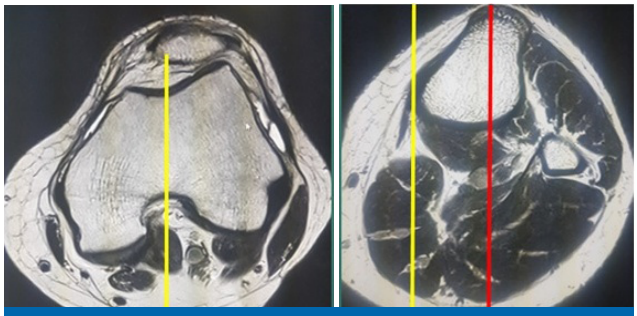
Patella Alta was assessed using Insall-Salvati Index- The ratio of patellar tendon length (measured from its attachment to tibial tuberosity upto the apex of patella on sagittal image) to the longest Superio-inferior patellar diameter. Patellar height ratio more than 1.3 was taken as patella alta [9,10] [Table/Fig-4].



[Table/Fig-1]: Measurement of lateral trochlear inclination angle between a line along the sub chondral bone of lateral trochlear facet (red line) and posterior surface of femoral condyles (brown line).
[Table/Fig-2]: Measurement of trochlear facet asymmetry ratio.



[Table/Fig-3]: Measurement of trochlear depth.
[Table/Fig-4]: Measurement of Patellar Tendon Height.



[Table/Fig-5]: Measurement of Tibial tuberosity to Trochlear groove distance (TTGD).

TTTG distance was calculated on axial section images. The distance between the middle of tibial tuberosity to the deepest point of trochlear sulcus was taken. Distance of <15mm was considered normal, 15-17mm – as borderline risk factor for patellar instability and > 20mm was considered as a definite risk factor for patellar instability [4] [Table/Fig-5].

STATISTICAL ANALYSIS

All data were expressed as mean±standard deviation, unless otherwise specified. Sensitivity and specificity were calculated for each parameter taking the cut off value described above as standard.

RESULTS

Out of the 20 study cases, 12 patients were female (60%) and 8 patients were male (40%). The mean age group was ~29 years and median age group was 27 years.

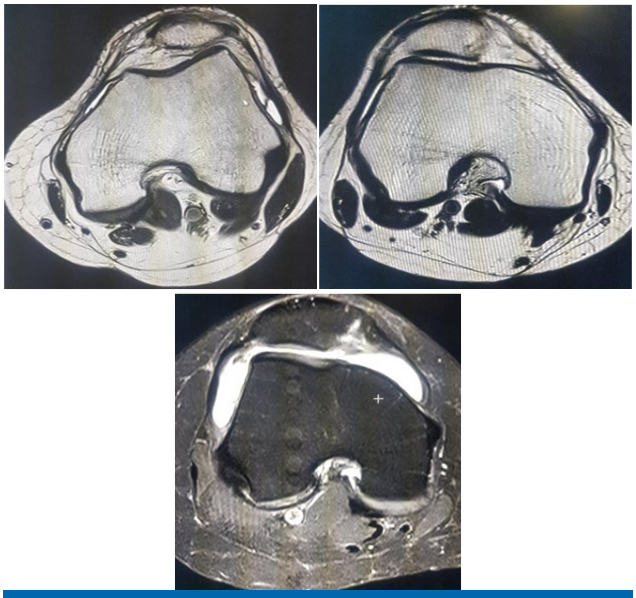
Morphology of trochlear dysplasia in study group:

Type A -10 cases (50%) [Table/Fig-6].

Type B- 1 case [Table/Fig-7].

Type C- 9 cases (45%) [Table/Fig-8].

Type D- Nil.



[Table/Fig-6]: Type A trochlear dysplasia showing shallow trochlear groove.
[Table/Fig-7]: Type B trochlear dysplasia showing flattened trochlea.
[Table/Fig-8]: Type C trochlear dysplasia showing hypoplastic medial trochlear facet.

The mean value with the standard deviation for different parameters are shown in the [Table/Fig-9,10].

The lateral inclination angle showed 95% sensitivity and 100% specificity respectively for the diagnosis of trochlear dysplasia. The trochlear facet ratio showed 75% sensitivity and 100% specificity for the diagnosis of trochlear dysplasia. The trochlear depth measurement showed 90% sensitivity and 100% specificity for the diagnosis of trochlear dysplasia.

Patella alta was seen in 18 out of 20 study cases and not seen in any of the control cases.

The tibial tuberosity to trochlear groove distance was > 20mm in 10 out of 18 cases. Five cases had borderline value between 15-17mm and 3 had values less than 15mm. None of the control group had values above 15mm.

Thus MRI Evaluation parameters show considerable amount of sensitivity and specificity in evaluation of risk factors for patellar instability.

S.No	Variable	n	Mean Value	Standard Deviation
1.	Lateral Inclination Angle	20	8.5 degree	2.68
2.	Trochlear Facet Ratio	20	39.5%	0.06
3.	Trochlear Depth	20	2.2 mm	2.21
4.	Insall - Salvati Index	20	1.43	1.43
5.	Tibial Tuberosity to Trochlear Groove (TTTG) Distance	18	19.28 mm	4.42

[Table/Fig-9]: Results in case group.

S.No	Variable	n	Mean Value	Standard Deviation
1.	Lateral Inclination Angle	20	15.45 degree	2.6
2.	Trochlear Facet Ratio	20	88%	0.05
3.	Trochlear Depth	20	5.5 mm	2.21
4.	Insall - Salvati Index	20	1.06	0.09
5.	Tibial Tuberosity to Trochlear Groove (TTTG) Distance	18	7.6 mm	3.61

[Table/Fig-10]: Results in control group.

DISCUSSION

Patello-femoral instability is a frequently seen condition in clinical practice. It leads to recurrent patellar dislocation and cartilage damage.

MRI plays an important role in identification of risk factors for patello-femoral instability [3].

In this study MRI parameters showed a great deal of sensitivity and specificity in diagnosing trochlear dysplasia. All the cases had one or the other criteria for the diagnosis of trochlear dysplasia.

Morphologic type	Burmann et al., [4] (n=118)	Our study (n=20)
Type A	51.69%	50%
Type B	25.42%	5%
Type C	16.95%	45%
Type D	5.93%	-

[Table/Fig-11]: Table depicting the comparison between the incidence of different morphological types.

Burmann et al., reported the incidence of different morphological types of trochlear dysplasia [4,7]. Thus, in both studies Type A was the commonest and type D was the least common morphological type seen. However, in our study we found type C to be next most common after Type B [Table/Fig-11].

Salzmann GM et al., showed similar results with Type A being most common type followed by Type B, C and D in descending order [11].

In this study the mean trochlear depth group was 5.5 mm which was correlating with value obtained by Pfirrmann et al., however in cases with trochlear dysplasia mean value was 2.2 mm in our study as compared to 0.7 mm in study conducted by Pfirrmann et al., even though the protocol used was same-taking measurement 3 cm above the tibio-femoral cleft, where the articular cartilage was seen [12].

Similar results were seen in study conducted by Escala JS et al., which showed mean trochlear depth of 3.3 mm in proximal part and 4.2 mm in distal part, thus showing that trochlear groove is shallower in the cranial part [13]. Thus, measurement should be taken in proximal part where trochlear articular cartilage is visible to avoid a false negative result.

The mean lateral trochlear inclination angle in our study was 8.2 degree which was correlating with 9.6 degree mean obtained in study conducted by Escala JS et al., [13]. Thus the measurement is more reliable when taking ~3cm from tibio femoral joint where the trochlear cartilage is visible.

Patella alta was seen in 90% of the cases in our study. In our study the mean value obtained was 1.43 in comparison to study conducted by Burmann et al., (1.23) [4]. In both studies no case of patella baja was seen.

Thus, Insall-Salvati index is a reliable and simple tool to assess the patellar height ratio which is an important risk factor for patello-femoral instability [9,10].

Lateralization of tibial tuberosity was seen in 55% of cases while borderline values were seen in 27% of cases. Similar results were seen in study conducted by Burmann et al., 49.60%. Thus, increased TTTG is an important risk factor for patello-femoral instability [4].

CT was used as gold standard for measurement of TTTG distance, however studies have shown that MRI can be used reliably for TTTG measurement as with the other parameters with advantage of being non ionizing modality and with added advantage of assessment of other ligament, cartilage, marrow abnormality [14].

Measurements for trochlear dysplasia and lateralization of tibial tuberosity are often commonly over looked during a routine MRI knee reporting unless a strong clinical history of recurrent patellar dislocation is present. Recognizing these anatomical abnormalities plays an important role especially in young adults as these can be surgically corrected.

Trochleoplasty is performed in cases of trochlear dysplasia [7]. Similarly medialization of tibial tuberosity is performed for patella alta and cases with increased TTTG distance [2].

However, MRI has certain limitations, for accurate and reproducible measurements and comparison with standards- the scan needs to be performed in an ideal manner.

For accurate measurements, the MRI should be performed with knee in flexion as physiologically there is lateral patellar inclination during extension which the habitual position for performing MRI knee. Thus, the radiologists must ensure that scans are performed with knee joint in 5-10 degrees of flexion [15]. Another limitation of our study was that TTTG was not taken in 2 out of 20 cases since the tibial tuberosity was not covered in these cases. Thus, in all cases tibial tuberosity should be included in the field of view.

CONCLUSION

MRI is the preferred imaging modality used in evaluation of suspected cases of patello-femoral instability especially in young adults. Standardized MRI parameters helps radiologists to assess the risk factors- trochlear dysplasia, patella alta and lateralization of tibial tuberosity and helps the orthopaedic surgeon in selecting the most optimal management such as trochleoplasty for trochlear dysplasia and medialization of tibial tuberosity to correct both patella alta and lateralization of tibial tuberosity.

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