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MRI - based Evaluation of Various Trochlear and Patellar Morphology Indices in Patients Referred with Patellar Instability at a Tertiary Care Center

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Abstract: ***Background: MRI is essential for identifying anatomical risk factors linked to patellar instability, aiding treatment decisions. Patients without these risk factors and minor medial stabilizer damage can often be managed conservatively. However, those with significant stabilizer damage and anatomical risk factors may require surgery. This study aimed to identify MRI markers of patellar instability. Key factors include increased tibial tubercle - trochlear groove (TT - TG) distance indicating lateralization of the tibial tuberosity, trochlear dysplasia (evident through reduced trochlear depth, increased lateral trochlear inclination, and trochlear facet asymmetry), and patella alta (marked by increased patellar height ratio). Aims: To evaluate trochlear and patellar predisposing factors on MRI in patients with patellar instability. Conclusion: MRI is a safe, accurate, and specific modality for diagnosing knee pathologies across age groups. It effectively detects types and grades of knee pathologies. MRI is the modality of choice in detecting various forms of trochlear and patellar factors predisposing to patellar instability***

Keywords: patellar instability, MRI diagnosis, trochlear dysplasia, tibial tubercle - trochlear groove distance, patella alta

1. Introduction

Patellar instability may be defined as inability of the patella to contain itself in the trochlear groove throughout the normal arc of knee movement. It encompasses a variety of injuries including patellar subluxation, dislocation and recurrent symptomatic instability interfering with the day to day living activities.[1] It largely affects young active individuals with a female preponderance.[2]

Magnetic resonance imaging (MRI) plays a crucial role in identifying anatomical risk factors associated with patellar instability[3], thereby aiding in the selection of appropriate treatment strategies. Patients without significant anatomical abnormalities and only mild injury to the medial stabilizing structures are often managed conservatively. In contrast, individuals with marked medial stabilizer injury and identifiable anatomical risk factors may benefit from surgical intervention.

This study aimed to evaluate the key anatomical contributors to patellar instability as visualized on MRI. The principal MRI markers include lateralization of the tibial tuberosity—quantified by an increased tibial tubercle–trochlear groove (TT–TG) distance—trochlear dysplasia, assessed through decreased trochlear depth, increased lateral trochlear inclination, and trochlear facet asymmetry, as well as patella alta, indicated by an increased patellar height ratio.[4]

2. Aims and Objectives

To evaluate trochlear and patellar predisposing factors on MRI in patients with patellar instability To identify MRI markers associated with patellar instability, with a focus on evaluating tibial tubercle - trochlear groove (TT - TG) distance, features of trochlear dysplasia (including trochlear depth, lateral trochlear inclination, and facet asymmetry), and patellar height ratios indicative of patella alta.

3. Research Methodology

This cross - sectional study was conducted at the Department of Radiodiagnosis, Akash Institute of Medical Sciences and Research Centre, Akash Hospital, Bengaluru. The study included patients presenting with clinical symptoms of patellar instability. A total of 20 cases were selected based on predefined inclusion and exclusion criteria.

Patients with a clinical history of patellar instability, including dislocation or relocation episodes. References for knee MRI for further evaluation of instability - related symptoms were included in the study.

Patients with MRI - incompatible implants or pacemakers. Patients with orthopnea or claustrophobia precluding MRI acquisition were excluded from the study.

All MRI examinations were performed using a 1.5 Tesla Siemens MRI scanner. Standard imaging sequences were acquired in axial, sagittal, and coronal planes with dedicated protocols for patellofemoral joint evaluation.

Trochlear dysplasia
The following parameters were used to evaluate trochlear dysplasia:

Lateral trochlear inclination
To calculate lateral trochlear inclination two lines were drawn, one along the subchondral bone of lateral trochlear

facet and other along the posterior aspect of condyles of femur. The angle between these two lines is the lateral trochlear inclination. The cutoff for trochlear dysplasia was an inclination angle of <11° [Figure 1 respectively].[5]

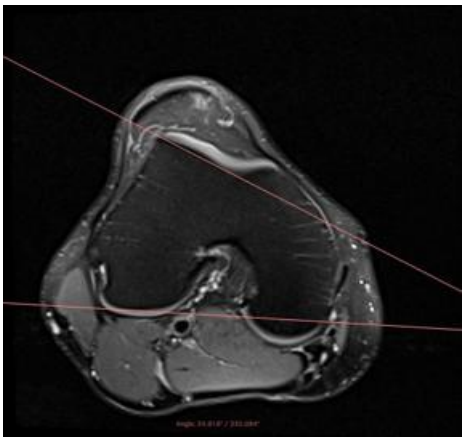


Figure 1: Lateral trochlear inclination

Trochlear facet asymmetry

To calculate trochlear facet ratio, length of the medial and lateral trochlear facets was measured. The ratio of medial to lateral trochlear facet was given as trochlear facet ratio and was measured both at the level of trochlear bone and cartilage. Trochlear facet asymmetry was characterized by a ratio which measured <40% and it indicated dysplasia [Figures 2 and 3 respectively].[6]

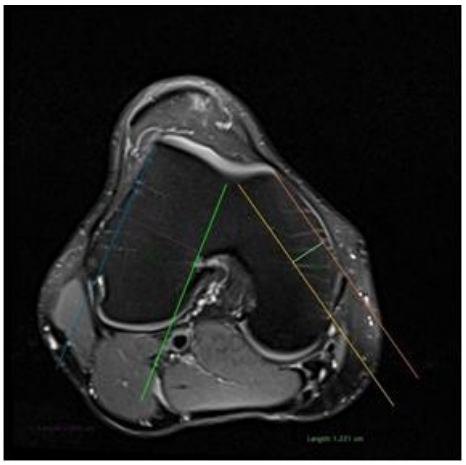


Figure 2: Trochlear facet asymmetry measured at the level of trochlear bone

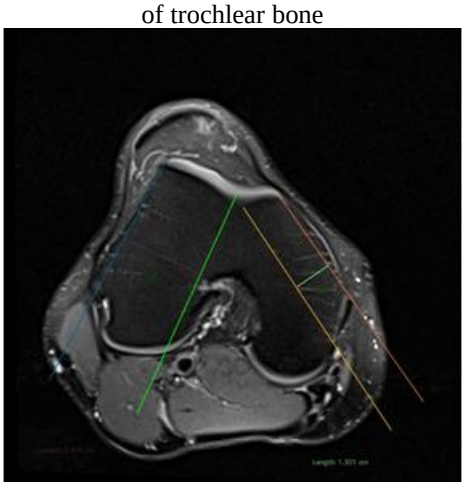


Figure 3: Trochlear facet asymmetry measured at the level of trochlear cartilage

Trochlear depth

A line was drawn along the posterior plane of femoral condyle. Three lines were drawn perpendicular to the aforementioned line. These three lines were drawn such that they depict maximum anteroposterior distance of medial and lateral trochlear facets (Line C and A) and the deepest sulcal point (Line B).

Trochlear depth was measured using the following equation: (A+C) /2–B. This value was measured both at the level of subchondral bone and trochlear cartilage. Trochlear dysplasia was diagnosed if trochlear depth was less than or equal to 3.0 mm [Figures 4 and 5 respectively].[6]

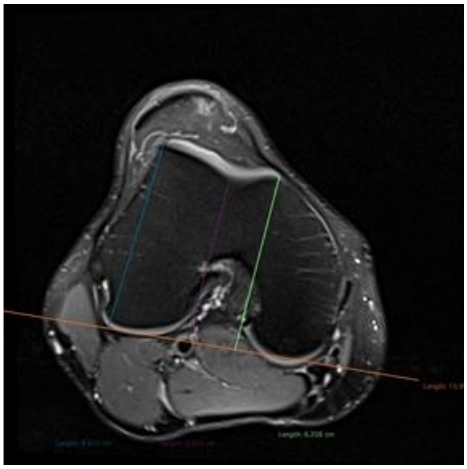


Figure 4: Trochlear depth measured at the level of trochlear bone

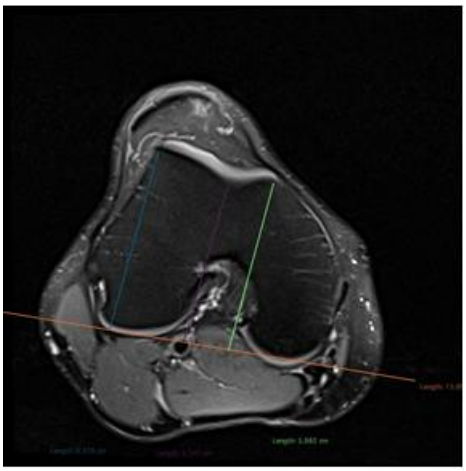


Figure 5: Trochlear depth measured at the level of trochlear cartilage

TT - TG distance

It was measured as a maximum distance from the midpoint of tibial tubercle to the deepest point of trochlea. Here, a line was drawn perpendicular to the posterior plane of femoral condyles such that it depicted deepest sulcal point. This line was copied into the transverse section showing tibial tubercle. Another line from the midpoint of tibial tubercle was drawn parallel to the aforementioned line. The distance between two lines was given as TT - TG distance. A value of more than 20 mm was taken as a cutoff and indicated marked lateralization of the tuberosity [Figure 6 respectively].[7]

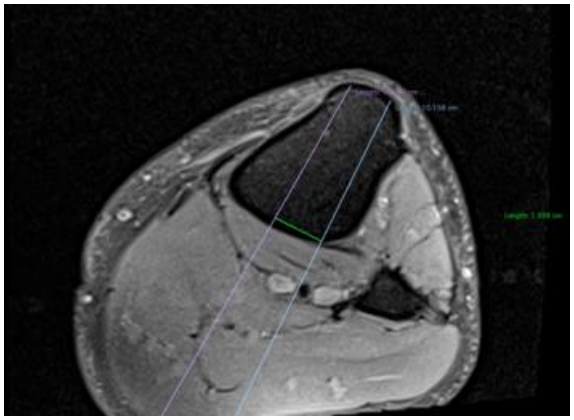


Figure 6: TT - TG distance measured between line 1 and line 2 on axial FSPD images depicted by line A. (Line 1 drawn from the middle of the tibial tubercle and Line 2 extrapolated from the deepest part of the trochlea using posterior plane of condyle as reference line).

Patellar height ratio

Patellar height ratio was evaluated on sagittal sections of knee MRI as a ratio between patellar tendon length and longest craniocaudal diameter of patella (Insall - Salvati ratio). A ratio measuring more than 1.30 indicated patella alta [Figure 7 respectively].[8]

Figure 7: Patellar height ratio measured on sagittal T1 - weighted turbo spin - echo MR images as B/A

Table 1: Various MRI predisposing factors of patellar instability, their normal and cutoff values in patients with patellar instability.[9]

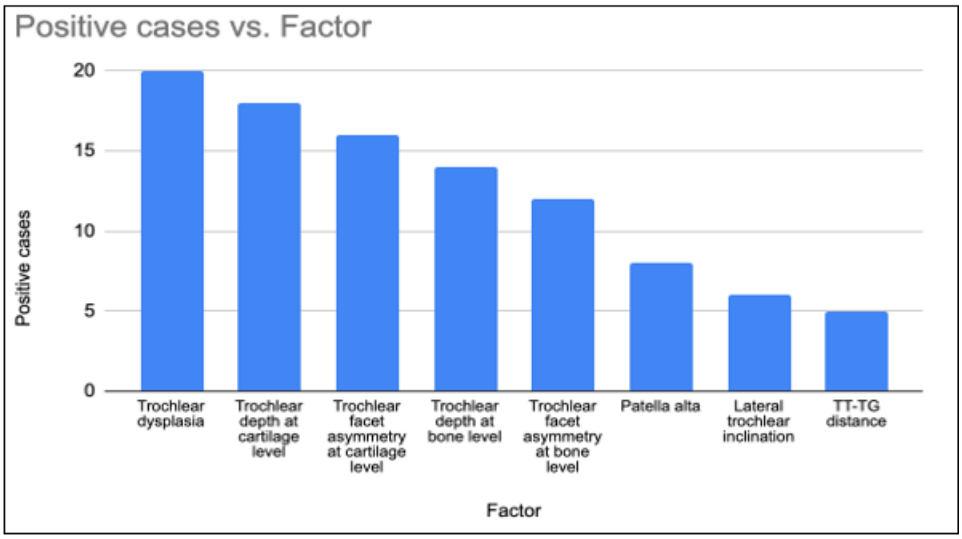
Factor	Normal Value	Cutoff Value
Trochlear Depth	>3 mm	<3 mm
Trochlear Facet ratio	>40%	<40%
Patellar height ratio	<1.3	>1.3
Lateral Trochlear Inclination	$>11^0$	$<11^0$
TT= TG distance	<20mm	>20mm

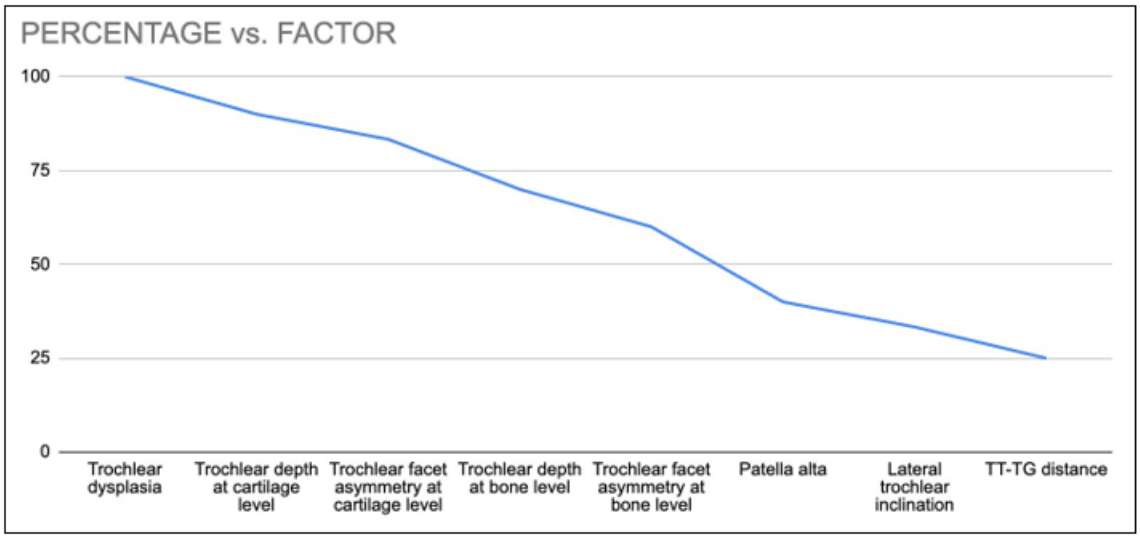
MRI: Magnetic resonance imaging.
TT- TG: Tibial tubercle- trochlear groove

4. Observation and Results

Factor	Positive cases	Total cases	Percentage %
Trochlear dysplasia	20	20	100
Trochlear depth at cartilage level	18	20	90
Trochlear facet asymmetry at cartilage level	16	20	83.33
Trochlear depth at bone level	14	20	70
Trochlear facet asymmetry at bone level	12	20	60
Patella alta	8	20	40
Lateral trochlear inclination	6	20	33.33
TT - TG distance	5	20	25

1) Eighteen cases (90%) and Fourteen cases (70%) out of 20 cases were positive for decreased trochlear depth when measured at the level of trochlear bone and cartilage, respectively.
2) Sixteen cases (60%) and Twelve cases (83.33%) out of 20 cases were positive for trochlear facet asymmetry when measured at the level of trochlear bone and cartilage, respectively.
3) Eight cases (40 %) were positive for patella alta.
4) Six cases (33.33%) were positive for decreased lateral trochlear inclination.
5) Five cases (25 %) had increased TT - TG distance





5. Conclusion

- MRI is an effective tool for evaluating patellar instability. Our study emphasizes that measuring trochlear depth and facet asymmetry at the level of trochlear cartilage yields more accurate results as predictors of instability compared to measurements at the trochlear bone.
- Among the factors contributing to patellar instability, trochlear dysplasia emerged as the most critical, with shallow trochlear depth being the strongest determinant, followed by trochlear facet asymmetry and lateral trochlear inclination.
- In contrast, patellar height ratio and TT - TG contributed less significantly.
- Patellar instability is more prevalent in females and individuals aged 25 years or younger.
- Radiologists should systematically evaluate and document all measurable risk factors on MRI, ensuring accurate parameter measurement to guide optimal treatment planning.

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