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Quantitative Assessment of Patellar Instability in Indian Population: A Magnetic Resonance Imaging Based Observational Study

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Abstract: ***Patellar instability is a common cause of knee dysfunction and anterior knee pain, especially in young and physically active individuals. Recurrence after non-surgical treatment is frequent, making accurate structural assessment essential for long-term management. Magnetic resonance imaging offers detailed visualization of bone contours, articular cartilage, and soft tissue structures, allowing detection of anatomical variations that contribute to instability. This study aimed to evaluate key magnetic resonance imaging-based morphological risk factors associated with patellar instability. This prospective observational study was conducted at a tertiary care centre in Mumbai over a period of three years, from July two thousand twenty-one to December two thousand twenty-four. Thirty-six individuals presenting with knee pain and a history of at least one documented episode of patellar instability underwent evaluation using a three Tesla magnetic resonance imaging system. Parameters assessed included the sulcal angle, patellar inclination angle, depth of the femoral trochlea, asymmetry of the trochlear facets, patellar height measured using the Insall–Salvati ratio, distance between the tibial tuberosity and the trochlear groove, and the degree of patellar tilt. The study demonstrated a high sulcal angle in most individuals, increased patellar height in a large proportion, and an increased patellar tilt in many cases. The distance between the tibial tuberosity and the trochlear groove was elevated in a significant subset. Trochlear dysplasia was the most frequent anatomical abnormality, and more than half of the individuals exhibited three or more structural risk factors. The findings indicate that abnormalities of the femoral trochlea, particularly trochlear dysplasia, play a central role in the development of patellar instability. Magnetic resonance imaging provides a comprehensive assessment of knee morphology and is an essential tool for identifying anatomical risk factors and guiding appropriate treatment planning.***

Keywords: Patellar instability, MRI, trochlear dysplasia, patella Alta, TT–TG distance

1. Introduction

The femur, tibia, and patella form the modified hinge joint, the largest synovial joint in the body and allows for rotation of the leg, along with flexion and extension. It plays a crucial role in maintaining the joint integrity and function. [1]

Patella dislocations account for 3% of all knee injuries. [2] The incidence of patellar instability in the general population is 5.8 per 100,000 and 29 per 100,000 in the 10 to 17-year-old age group. [2,3] Many cases of first-time dislocations are treated conservatively. However, the chances of recurrence after conservative treatment can be up to 15 to 44%. [3] Patients with a history of two or more dislocations have a 50% chance of recurrent dislocation episodes in the future. [2] A previous patellar dislocation is associated with the highest risk of persistent patellar instability later in life.

Magnetic Resonance Imaging (MRI) plays a crucial role in the diagnosis, management, and preoperative planning for patellar instability due to its detailed soft-tissue resolution and ability to assess structures such as ligaments, cartilage, and bone morphology. [4] It helps in the decision-making process for both conservative and surgical treatment strategies, improving patient outcomes. Furthermore, it offers valuable information on trochlear dysplasia, patellar height (e.g., patella Alta), and the tibial tuberosity-trochlear groove (TT-TG) distance, which are important factors contributing towards patellar instability and management [5].

This study investigates the role of MRI in assessing the risk factors associated with patellar instability. It also aims to identify various contributing factors that lead to patellar instability.

2. Materials and methods

It was a hospital based observational study, undertaken at Urban Tertiary Care Centre in Mumbai. The study was conducted over a period of 3 years from July 2021 to December 2024.

Selection of participants: the study participants comprised of patients referred for knee pain who presented during the study period.

Inclusion Criteria: All adult and elderly patients with history of knee pain and previous one episode of patellar instability.

Exclusion Criteria: Patient with history of claustrophobia. Patients with history of cardia pacemakers, metallic foreign bodies and implants contraindicated for MRI. Patient with previous history of Surgery. Recurrent history of dislocations and trauma.

Sample Size: The sample size was determined using the formula: $N=2*(Z\alpha/2+Z\beta)^2*\sigma 2/\delta^2$ where: N is the required sample size per group. $Z\alpha/2$ is the critical value of the normal

distribution at α/2 (for a 90% confidence level, α = 0.05, $Z\alpha/2$=1.645). $Z\beta$ is the critical value of the normal distribution at β (for 80% power, $Z\beta$=0.84). σ is the standard deviation. δ is the minimum clinically significant difference. According to the study by Arendt EA et al., the standard deviation of lateral patellar displacement on MRI was taken as 3.0 mm. [6] For our study, the minimum clinically significant difference was assumed to be 1.0 mm. A sample size of approximately 36 participants is taken.

Sampling Method: the patients were selected via convenience sampling. Patients who gave valid consent and fulfilled the above-mentioned inclusion and exclusion criteria were subjected to MRI of the affected knee. The MRI was performed on 3 Tesla Philips Ingenia MRI machine.

Study Protocol: questionnaire consisting of Demographic details like Age, gender, height, and weight. Detailed History related to duration of symptoms, duration of disease, treatment taken followed by Clinical examination and Investigations. All the patients were subjected to MRI evaluation of the affected knee joint.

Imaging was done on 3 Tesla Philips Ingenia MRI machine.

Patient's Position: Routine knee MRI positioning.

- Feet first supine.
- Knee positioned in knee coil and immobilised with cushion.
- Position of slight flexion and internal rotation.

MRI Protocol: The following sequences of the affected joint will be taken.

- PD FS axial and sagittal.
- PD axial.
- T1 Coronal.
- STIR Coronal.
- Gradient-echo fast-field echo coronal.
- Additional MRI sequences were used whenever required.

Statistics

Data was entered into Microsoft excel and analyzed using SPSS V15.0 (Statistical Package for Social Sciences, Version 15.0) package. Comparison of means of 2 groups will be carried out by unpaired t test for normal data and by Mann Whitney U test for non- normal data. Chi square test will be applied to compare percentages of more than 2 groups. All statistical tests will be two tailed. Alpha (α) Level of Significance will be taken as P<0.05.

3. Results

Majority of the participants were under < 50yrs 32(88.8%). 20(55.6%) had left sided patellar involvement. limitation of Movements at the time of presentation was seen among 32(88.9%).

Table 1: Distribution of study participants based on clinical presentation

S no	Variable	Category	Number (%)
1	Age	<20	8(22.4)
	Youngest age :17year Eldest age: 52year.	20-30	8(22.4)
		30-40	8(22.4)
		40-50	8(22.4)
		>50	4(11.2)
2	Gender	Male	4(11.1)
		Female	32(88.9)
3	Laterality	Left	20(55.6)
		Right	16(44.4)
4	Limitation of movements	Yes	32(88.9)
		No	4(11.2)
5	Systemic illness (Diabetes mellitus and hypertension)	Yes	12(33.3)
		No	24(66.7)

The MRI findings of the study participants are shown in Table 3, it shows the basic pattern of each parameters measured, majority of the participants had high sulcal angle, high patellar Alta, high TT-TG and patella tilt angle.

Table 2: MRI parameters measured

Sl no	Variable	Category	Number (%)
1	Sulcal angle	Normal (135±100)	8(22.2)
		> 1450	28(77.8)
2	Patellar inclination Angle (PIA)	Normal (>110)	32(88.9)
		Low (<110)	4(11.1)
3	Trochlear depth	Normal (>3mm)	28(77.8)
		Low (<3 mm)	8(22.2)
4	Trochlear Facetal Asymmetry	Normal (>40 %)	32(88.9)
		abnormal (<40 %)	4(11.1)
5	Patellar Alta	Normal (0.8-1.2)	8(22.2)
		High (> 1.2)	28(77.8)
6	Tibial tuberosity-trochlear groove (TT-TG)	Normal (10-15mm)	20(55.6)
		High (>15 mm)	16(44.4)
7	patella Tilt angle (PTA)	Normal (<200)	8(22.2)
		High (>200)	28(77.8)

High sulcal angle (> 145^0) and low trochlear depth (<3mm) were most commonly seen among trochlear dysplasia patients. These two parameters along with patellar inclination angle and trochlear facetal asymmetry were considered for Trochlear dysplasia.

Table 3: Risk factors

S. No	Risk factor	Category	Number	No of cases	Percent%
1	Trochlear dysplasia	a) Sulcal angle	28	36	77.8
		b) Patellar inclination angle	4	36	11.1
		c) Trochlear facetal asymmetry	4	36	11.1
		d) Trochlear depth	8	36	22.2
2	MRI Risk factors present in each patient	4	8	36	22.2
		3	20	36	55.6
		2	4	36	11.1
		1	0	36	0

Majority of the participants had 3 or more risk factors of patellar instability 20(55.6%), nearly 8(22.2%) participants had 4 risk factors. Only 4(11.1%) of the participants had no MRI risk Factors for patellar instability. 32(88.8%) had at least two of the five risk factors of patellar instability

Table 5: Association between age at presentation and radiological factors of patellar instability
P<0.05 is statistically significant

S. No	Variable	Category	Age					X^2 value	P value
			<20	20-30	30-40	40-50	>50		
1	Sulcal angle (SA)	Normal (125-145)	4(50)	0(0)	0(0)	0(0)	4(100)	24.42	<0.001
		>145	4(50)	8(100)	8(100)	8(100)	0(0)		
2	Patellar inclination Angle (PIA)	>11	4(50)	8(100)	8(100)	8(100)	4(100)	15.75	<0.05
		<11	4(50)	0(0)	0(0)	0(0)	0(0)		
3	Trochlear depth (TD)	>3	8(100)	4(50)	8(100)	4(50)	4(100)	12.85	<0.05
		<3	0(0)	4(50)	0(0)	4(50)	0(0)		
4	TT-TG	<15mm	4(50)	8(100)	0(0)	4(50)	4(100)	19.8	<0.005
		>15mm	4(50)	0(0)	8(100)	4(50)	0(0)		
5	patella Tilt angle (PTA)	<20	0(0)	0(0)	0(0)	4(50)	4(100)	24.42	<0.001
		>20	8(100)	8(100)	8(100)	4(50)	0(0)		
6	Patellar Alta (PA)	<1.2	0(0)	0(0)	0(0)	4(50)	4(100)	24.42	<0.001
		>1.2	8(100)	8(100)	8(100)	4(50)	0(0)		
7	Trochlear Facetal Asymmetry (TFA)	>40	8(100)	4(50)	8(100)	8(100)	4(100)	15.75	<0.05
		<40	0(0)	4(50)	0(0)	0(0)	0(0)		

Case 1: A 25 year female patient presented with complaint of right knee pain since 2 months.

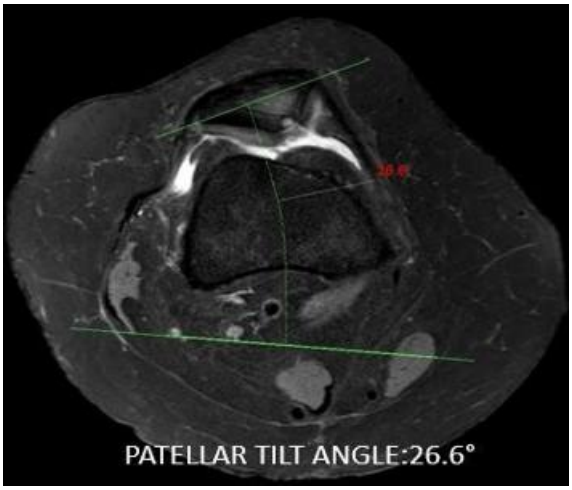

Figure 1: PDFS AXIAL image shows increased lateral patellar tilt angle (26.60)

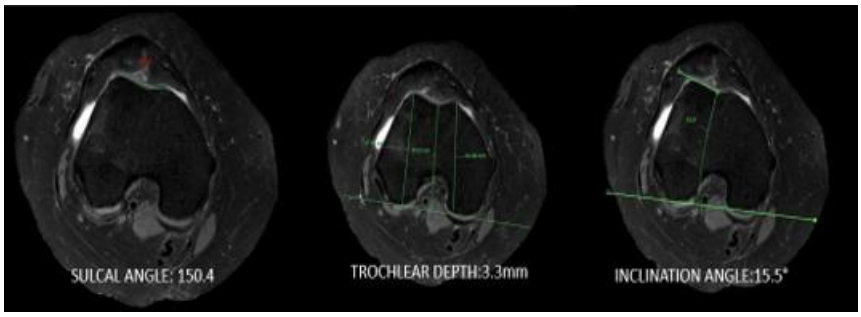

Figure 2: PDFS Axial Images Shows

1) Sulcal Angle: Increased (Normal<1450)
2) Trochlear Depth Angle: Normal
3) Inclination Angle: Increased.

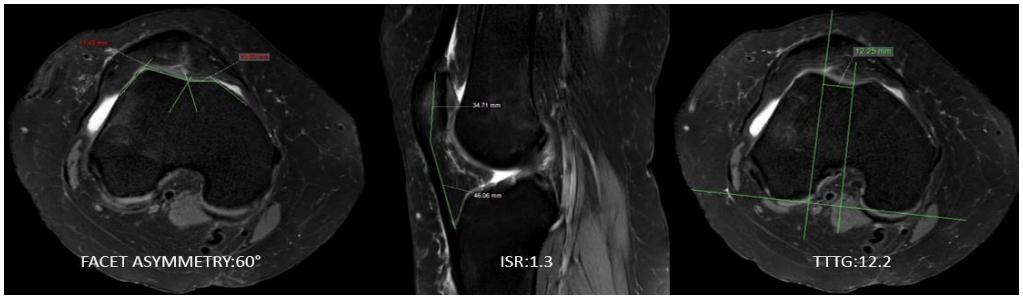

Figure 3: PDFS Axial and Saggital Images Shows

1) Facet Asymmetry: Normal
2) Insal- Salvatti Ratio: 1.3(Increased) Patellar Alta
3) TT-TG: Normal.

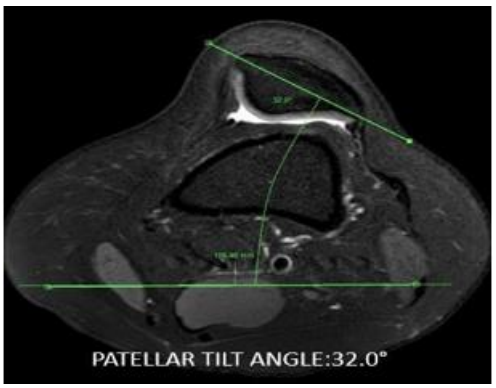

Figure 1: PDFS AXIAL image shows increased lateral patellar tilt angle (32.00)

Case 2: A 31 year old female patient presented with complain of left knee pain and since 3 months. No h/o trauma.

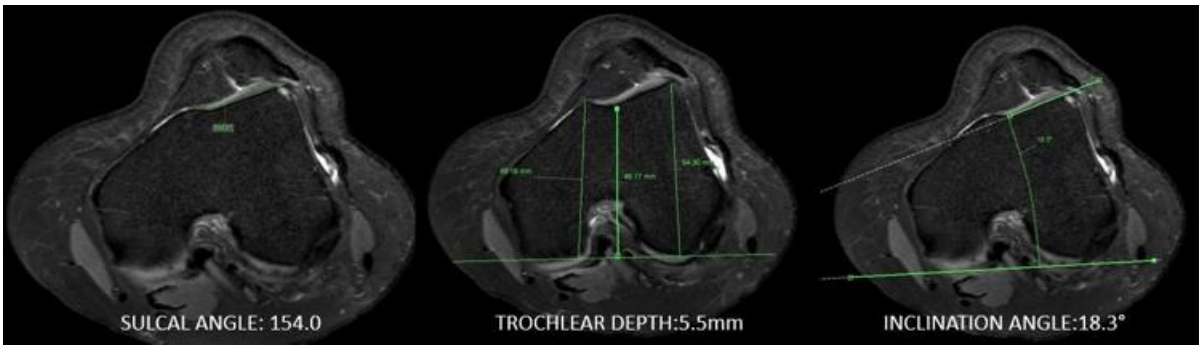

Figure 5: PDFS Axial Images Shows

1) Sulcal Angle: Increased (Normal<1450)
2) Trochlear Depth Angle: Normal
3) Inclination Angle: Normal.

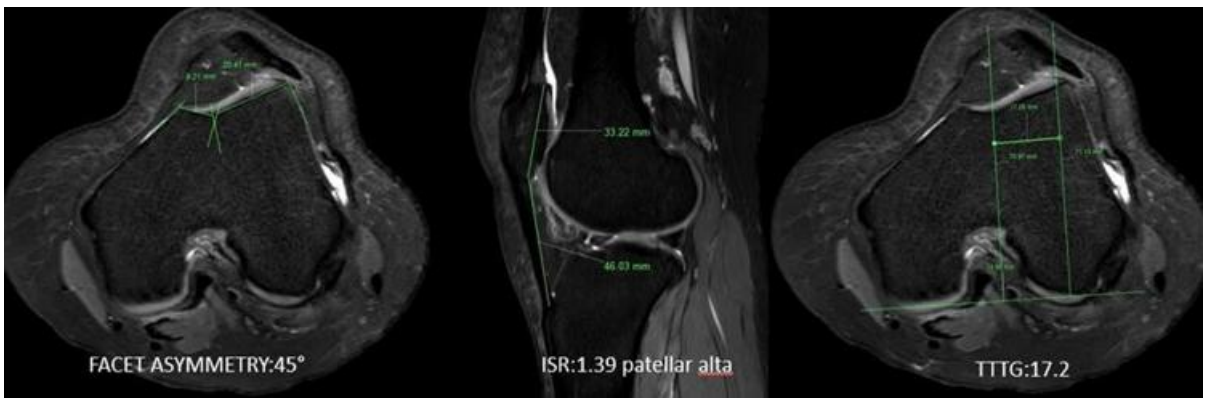

Figure 6: PDFS Axial and Saggital Images Shows

1) Facet Asymmetry: Normal
2) Insal-Salvatti Ratio:1.3(Increased) Patellar Alta
3) TT-TG: Normal.

Case 3: A 17 year female patient presented with complain of left knee pain since 2 years and No h/o trauma.

Figure 7: PDFS Axial Image Shows Increased Lateral Patellar Tilt Angle (24.0^0)

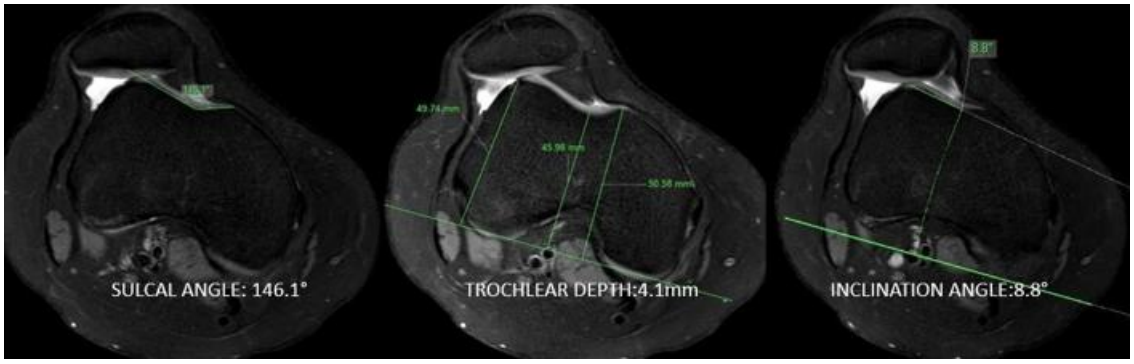

Figure 8: PDFS Axial Images Shows

1) Sulcal Angle: Increased (Normal<145^0)
2) Trochlear Depth Angle: Normal
3) Inclination Angle: Abnormal (<11^0)

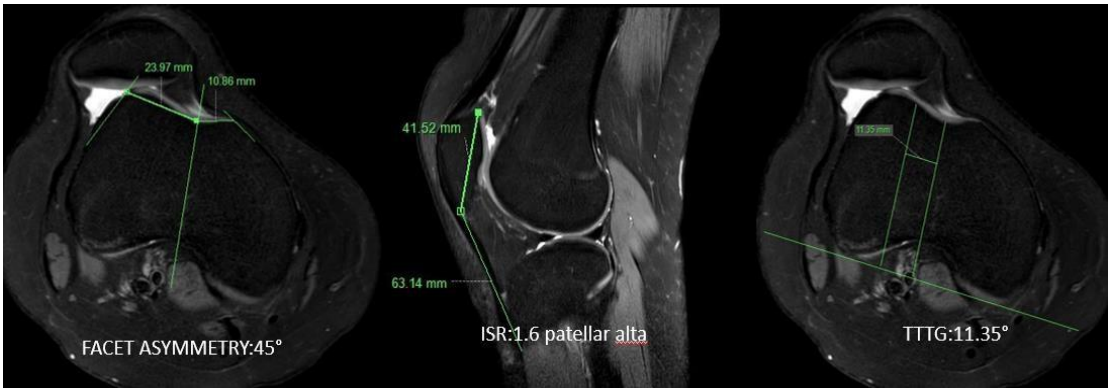

Figure 9: PDFS Axial and Sagittal Images Shows

1) Facet Asymmetry: Normal
2) Insal-Salvatti Ratio: 1.3(Increased) Patellar Alta
3) TT-TG: Normal.

Case 4: A 50 year female patient presented with pain in left knee since 1 month, increased on walking and h/o sudden jerk while doing workout 2 months back

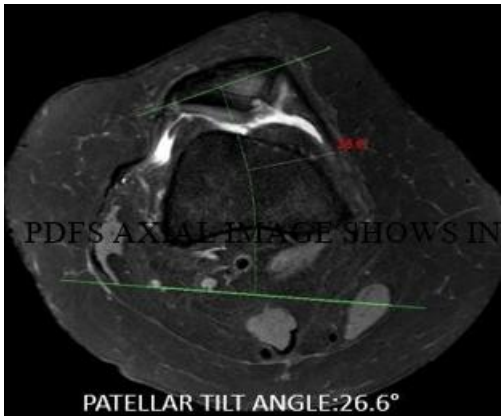

Figure 10: PDFS Axial Image Shows Increased Lateral Patellar Tilt Angle (26.6^0)

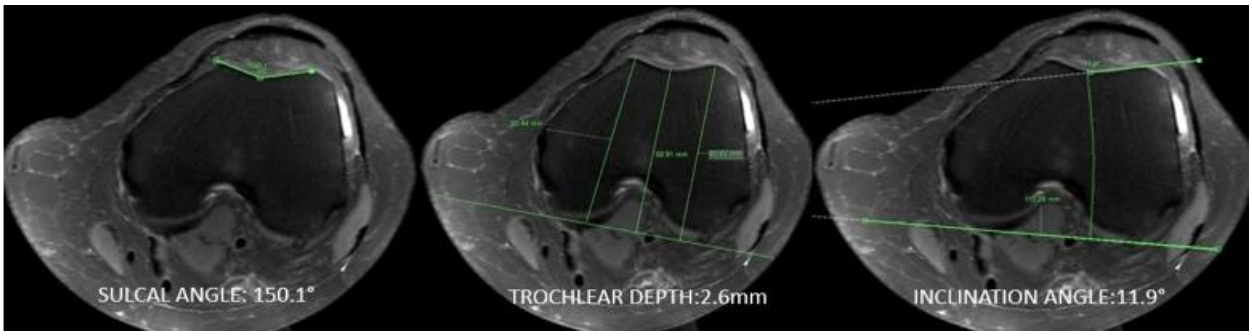

Figure 11: PDFS Axial Images Shows

1) Sulcal Angle: Increased (Normal<1450)
2) Trochlear Depth Angle: Abnormal (>3MM).
3) Inclination Angle: Normal.

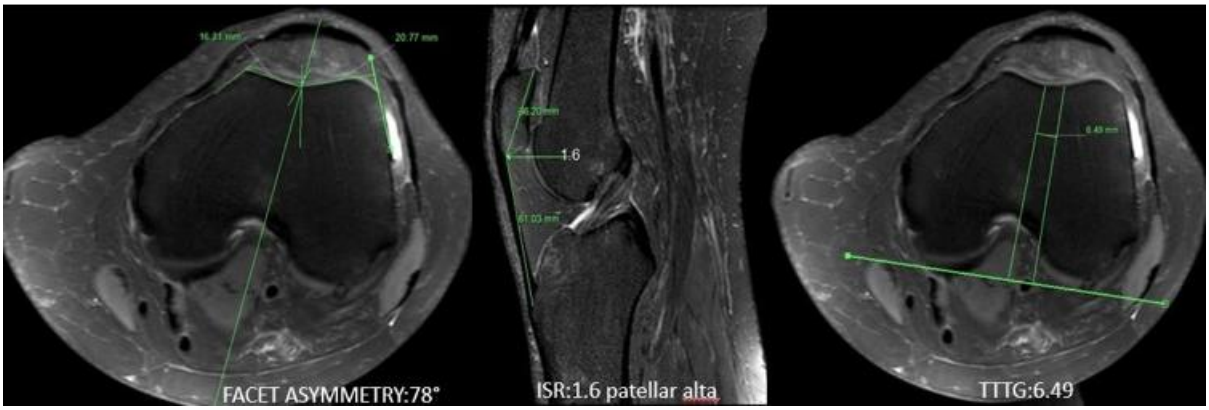

Figure 12: PDFS Axial and Saggital Images Shows

1) Facet Asymmetry: Normal
2) Insal- Salvatti Ratio: 1.3(Increased) Patellar Alta
3)TT-TG: Normal.

4. Discussion

Patellar instability is a condition in which patella is unable to contain itself in the femoral trochlea during normal movement of knee joint. In our study majority of the patellar instability patients were females. This is consistent with other study findings as Patellar instability is common seen among young adults involved in sports related activities with a higher incidence seen among females when compared to males. [7,8] A similar study done in Nepal by Kapil Adhikari, Mukesh Kumar Gupta, et al, an MRI based evaluation of patello femoral joint. they included knee of total 60 patients, out of which 28 were male (46.7%) and 38 were female (53.3%). Age ranged from 12 to 59 years, with a mean age of 33.9 years (±10). 25 patients (41.7%) presented with complain of anterior knee pain and 35 patients (58.3%) complained of giving way of knee while walking. [9]

In our present study, patellar instability cases were reported more on the left knee joint, with limitation of movements noted among 32(88.9%). The risk of suffering another dislocation is higher after having suffered a prior dislocation, especially when the first-time dislocation occurred at a young age. Study conducted by Schubert I et al, comprised 104 cases, consisting of 54 children and 50 adults. The most common mechanism of injury in children and adults was rotational trauma. The adult group consisted of 33 first-time and 17 recurrent dislocations.

Instability of patellofemoral joint is associated with the presence of various anatomic predisposing factors. MRI plays an important role to identify various risk factors for patellar instability which includes trochlear dysplasia, high-riding patella (patella Alta), and abnormal TT-TG distance.

In this study, we have used different parameters to assess trochlear dysplasia, namely, sulcal angle, trochlear depth, trochlear inclination angle, and trochlear facet ratio. Carrillon et al. [12,13] and Diederichs et al. [14] also described the use of these parameters in the assessment of trochlear dysplasia with excellent values in identification and classification. In trochlear dysplasia, there is diminished engagement between femoral trochlea and patella due to a shallow TG, thereby leading to patellar instability.[15] In our present study, 8(22.2%) of the patients were positive for decreased trochlear depth when measured at the level of trochlear cartilage, respectively, while 4(11.1%) cases were positive for trochlear facet asymmetry when measured at the level of trochlear cartilage, respectively. This corresponds to the study done by Pfirrmann et al. [16] where a specificity and sensitivity of 96% and 100%, respectively, were established for both trochlear facet asymmetry and trochlear depth as a diagnostic tool for patellar instability

Trochlear depth and trochlear facet asymmetry were measured at the level of trochlear cartilage (in accordance with Escala et al. [17]) (in accordance with Diederichs et al. [31] and Pfirrmann et al. [16]).

Increased Tibial tuberosity- trochlear groove (TT-TG) pertains to laterally placed TT in relation to TG which leads to increased lateral pull of patellar tendon over patella leading to increased risk of lateral dislocation. Camp et al. [18, 19] in their study showed that TT-TG distance was increased in 56–93% of patients suffering from patellar instability. However, only 16 cases (44.4%) were positive for increased TT-TG distance in our study.

In cases of high-riding patella (patella Alta), contact between the femoral trochlea and patella is reduced during early phase of knee flexion which leads to patellar dislocation. Patellar height can be evaluated using different parameters. We used Insall-Salvati ratio to measure patella Alta with a cutoff of more than 1.2. 12 of 28 cases (77.8%) were positive for patella Alta in our study. Escala et al. [18] used Insall-Salvati ratio with a cutoff of more than 1.2 to diagnose patella Alta in patient with patellar instability and found a sensitivity of 79% and specificity of 67.6%. The smaller number of cases in our study could be attributed to higher cut off used in our study.

Askenberger *et al*. evaluated 103 patients with age <14 years for dysplastic trochlea, TT to TG distance, patellar tilt, and patella Alta on MRI. It was found that 79% of patients with LPD had at least two out of four above-mentioned risk factors of patellar instability, in comparison to only 7% of patients in the control group. This corresponds to our study in which 32(88.8%) had at least two of the five risk factors of patellar instability. [20]

First episode of dislocation at a younger age group has constantly been recognized as a major risk factor for recurrent LPD in majority of studies. Balcarek *et al*. [21] in their study established a statistically significant odds ratio for recurrence of patellar dislocation, when the first episode of dislocation was at an age <16 years in comparison to a later onset of the first episode. In our present study 16(44.4%) of the cases have a history of past dislocations.

5. Conclusion

According to our study, trochlear depth and facet asymmetry produce better results as a predisposing factor for instability of the patella when measured at the level of trochlear cartilage as compared to trochlear bone. Most critical factor responsible for patellar instability is trochlear dysplasia.

6. Limitations

A major limitation of our study was the small sample size, since it was a pilot study we included 36 patients, a large sample size will be needed to extrapolate the results to a wider population. Another limitation was lack of controls in our study. A larger sample size with a control group would definitely be more validating the results. The assessment of ligaments and surrounding soft tissue structures was not included, which may limit the comprehensive evaluation of the affected region.

References

[1] Fithian DC, Paxton EW, Stone ML, et al. Epidemiology and natural history of acute patellar dislocation. Am J Sports Med 2004;32(5):1114–1121.Exerc 2008;40(4):606–611.
[2] Fithian DC, Paxton EW, Stone ML, Silva P, Davis DK, Elias DA, White LM. Epidemiology and natural history of acute patellar dislocation. Am J Sports Med. 2004 Jul-Aug;32(5):1114-21.
[3] Hawkins RJ, Bell RH, Anisette G. Acute patellar dislocations. The natural history. Am J Sports Med. 1986 Mar-Apr;14(2):117-20.
[4] Sillanpää PJ, Peltola E, Mattila VM, Kiuru M, Visuri T, Pihlajamäki H. Femoral avulsion of the medial patellofemoral ligament after primary traumatic patellar dislocation predicts subsequent instability in men: a mean 7-year nonoperative follow-up study. Am J Sports Med. 2009 Aug;37(8):1513-21.
[5] Stefancin JJ, Parker RD. First-time traumatic patellar dislocation: a systematic review. *Clin Orthop Relat Res*. 2007; 455:93-101.
[6] Arendt EA, Askenberger M, Agel J, Tompkins MA. Risk of Redislocation after Primary Patellar Dislocation: A Clinical Prediction Model Based on Magnetic Resonance Imaging Variables. Am J Sports Med. 2018; 46: 3385–3390.
[7] Fithian DC, Paxton EW, Stone ML. Epidemiology and natural history of acute patellar dislocation. Am J Sports Med 2004; 32: 1114-21.
[8] Sillanpää P, Mattila VM, Iivonen T, Visuri T, Pihlajamäki H. Incidence and risk factors of acute traumatic primary patellar dislocation. Med Sci Sports Exerc 2008; 40:606-11.
[9] Adhikari K, Gupta MK, Devkota K, Baral P, Koirala S. Magnetic Resonance Imaging Evaluation of

Patellofemoral Joint. J Nepal Health Res Counc 2021 Jan-Mar;19(50): 122-6

[10] Schubert I, Morris P, Dickschas J, Strohm PC. The Impact of Anatomical Predisposition and Mechanism of Trauma on Dislocation of the Patella: A Retrospective Analysis of 104 Cases. *Journal of Personalized Medicine*. 2023; 13(1):84. https://doi.org/10.3390/jpm130100841.

[11] Wolfe S, Varacallo M, Thomas JD, Carroll JJ, Kahwaji CI. Patellar Instability. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 [cited 2024 Sep 5]. Available from: http://www.ncbi.nlm.nih.gov/books/NBK482427/

[12] White AE, Otlans PT, Horan DP, Calem DB, Emper WD, Freedman KB, Tjoumakaris FP. Radiologic Measurements in the Assessment of Patellar Instability: A Systematic Review and Meta-analysis. Orthop J Sports Med. 2021 May 20;9(5):2325967121993179.

[13] Carrillon Y, Abidi H, Dejour D, Fantino O, Moyen B, TranMinh VA. Patellar instability: Assessment on MR images by measuring the lateral trochlear inclination-initial experience. Radiology 2000; 216: 582-5.

[14] Diederichs G, Issever AS, Scheffler S. MR imaging of patellar instability: Injury patterns and assessment of risk factors. Radiographics 2010; 30: 961-81.

[15] Fulkerson JP. Disorders of the Patellofemoral Joint. 4th ed. Philadelphia, PA: Lippincott, Williams, and Wilkins; 2004.

[16] Pfirrmann CW, Zanetti M, Romero J, Hodler J. Femoral trochlear dysplasia: MR findings. Radiology 2000; 216: 858-64.

[17] Escala JS, Mellado JM, Olona M, Giné J, Saurí A, Neyret P. Objective patellar instability: MR-based quantitative assessment of potentially associated anatomical features. Knee Surg Sports Traumatol Arthrosc 2006; 14: 264-72.

[18] Balcarek P, Radebold T, Schulz X, Vogel D. Geometry of Torsional Malalignment Syndrome: Trochlear Dysplasia but Not Torsion Predicts Lateral Patellar Instability. Orthop J Sports Med. 2019 Mar 15;7(3):2325967119829790.

[19] Camp CL, Stuart MJ, Krych AJ, Levy BA, Bond JR, Collins MS, et al. CT and MRI measurements of tibial tubercle-trochlear groove distances are not equivalent in patients with patellar instability. Am J Sports Med 2013; 41: 1835-40.

[20] Askenberger M, Janarv PM, Finnbogason T, Arendt EA. Morphology and anatomic patellar instability risk factors in first-time traumatic lateral patellar dislocations: A prospective magnetic resonance imaging study in skeletally immature children. Am J Sports Med 2017; 45: 50-8.

[21] Balcarek P, Oberthür S, Hopfensitz S, Frosch S, Walde TA, Wachowski MM, et al. Which patellae are likely to redislocate? Knee Surg Sports Traumatol Arthrosc 2014; 22: 2308-14.