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Investigating the Relationship between Chondromalacia and Patellar Position in Magnetic Resonance Imaging Scans of Patients

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Abstract

Background: Patellar chondromalacia (CMP) is a common disorder and also a natural consequence of aging. Magnetic Resonance Imaging (MRI) has emerged as a potent non-invasive method for assessing patellar cartilage damage. This study investigated the relationship between chondromalacia and the position of the patella in in MRI scans of patients referred to Imam Khomeini Hospital. **Method:** In this cross-sectional study, patients who underwent knee MRI for any reason and were eligible for a diagnosis of chondromalacia based on diagnostic criteria were included. The information obtained from the MRI, including the position of the patella (alta and baja) and knee deformity, was recorded in a data collection form by an experienced radiologist. **Results:** According to the results, 116 (70.3%) of the patients were female and 49 (29.7%) were male. There was no significant association between patellar position and gender ($p = 0.27$), history of surgery and gender ($p = 0.64$), or history of trauma and gender ($p > 0.001$). Among the independent variables (age, gender, weight, and history of surgery), only history of trauma had a significant linear relationship with the types of patella positions. **Conclusion:** Findings of this study revealed that patellar position is identified as a predisposing factor for chondromalacia. It is recommended that future prospective studies, with larger sample sizes and including control groups, investigate the relationship between chondromalacia and patella position on MRI in patients.

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Introduction

Patellar chondromalacia (CMP) is a common disorder and also a natural consequence of aging. Major underlying accelerating factors include trauma, weight-bearing issues, vascular insufficiency, and structural factors (abnormally high or low patella, genu valgum, and femoral condyle abnormalities)[1-4].

The primary definition of patellar chondromalacia involves the softening of the cartilage layer of the patella or a phenomenon where the patellar cartilage layer is no longer as densely healthy as before.

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'Chondromalacia' is derived from Greek words: 'chondros' meaning cartilage and 'malakia' meaning softening[5].

Patellar chondromalacia, also known as runner's knee, is a common cause of anterior knee pain (AKP) among young individuals, especially young female athletes, characterized by anterior knee pain associated with visible changes in the patellar cartilage [6].

To diagnose this condition, it has been stated that physical symptoms such as anterior knee pain, effusion, quadriceps muscle atrophy, and crepitus behind the patella provide useful information for diagnosing CMP. However, none of these symptoms are considered specific to CMP. A reliable diagnosis of CMP requires ruling out conditions that can lead to AKP syndrome symptoms, such as patellar malalignment, osteochondral injury, meniscal tears, Hoffa's syndrome, and synovial plica, as there is a significant difference in the treatment of these conditions [7]

In clinical practice, various indices are used to evaluate patellar position. These include Insall-Salvati (IS), modified Insall-Salvati (mIS), Caton-Deschamps (CD), and Blackburne-Peel (BP) indices. Since mild patellar chondromalacia is often overlooked, patients with CMP are susceptible to osteoarthritis (a degenerative joint disease caused by the breakdown of joint cartilage and bone). Due to the limited therapeutic potential for these patients, cartilage lesions increase over time. However, in older individuals, age-related knee osteoarthritis may lead to CMP. [8]

Patellar chondromalacia can be diagnosed in patients who have undergone MRI imaging regardless of the clinical diagnosis. Although arthroscopy is generally considered the gold standard for diagnosis, MRI has become a powerful non-invasive tool for examining patellar cartilage lesions [9]MRI is also used to monitor the effects of treatment on cartilage lesions [10]Outerbridge first described a primary grading system for patellar chondromalacia based on surgical findings[11]

As mentioned, patellar position is important as it can be a significant predisposing factor for chondromalacia. An important point is that patella baja can also be a significant factor, separate from patella alta, in predisposing an individual to chondromalacia. This issue is crucial because, given the very rare occurrence of patella baja, this deformity may be overlooked as a predisposing factor for chondromalacia by the general public and even by physicians [12]. For instance, Mehl and colleagues considered patella alta as a predisposing factor[13].

Patella alta is defined by the presence of two out of four criteria:

IS > 1.37 for women and IS > 1.27 for men.

mIS > 1.95 for women and mIS > 1.88 for men.

CD > 1.42 for women and CD > 1.36 for men.

BP > 1.16 for women and BP > 1.12 for men.

Patella baja is defined by the presence of one of two criteria: IS <0.8 and CD <0.6.

Chondromalacia is divided into 5 grades based on MRI findings:

Grade 0 indicates normal cartilage.

Grade 1 indicates the presence of signal changes in the cartilage with an intact joint surface.

Grade 2 is for cartilage lesions that include less than 50% of cartilage depth.

Grade 3 is for cartilage lesions that extend beyond 50% of the cartilage depth but do not reach the bone.

Grade 4 involves the entire thickness of the cartilage and bone marrow edema [14, 15] .

Given the aforementioned points and the importance of early and appropriate diagnosis and treatment of patellar positional deformities, and considering the absence of similar studies in Iran, this study aims to investigate the relationship between chondromalacia and patellar position. The results of this study can highlight the importance of assessing patellar position in individuals at risk of chondromalacia, prevent excessive diagnostic and treatment costs, and improve patients' quality of life.

In a study conducted by Ozel in 2020 in Turkey, the relationship between early chondromalacia and patellar position was investigated. Patients aged 18 to 40 with advanced chondromalacia were studied. The findings indicated that both patella alta and baja were recognized as predisposing factors for chondromalacia. The modified Insall-Salvati index was the best measurement for defining patella alta. The final conclusion of this study states that both patella alta and patella baja predispose individuals to chondromalacia. Patella baja is rare, hence often not mentioned as a predisposing factor. The modified Insall-Salvati index was the best index for patella alta and correlated well with other indices. BP cannot be optimally calculated because determining the tibial plateau location seems difficult due to its three-dimensional and complex structure.[12]

In a study conducted by Özdemir and colleagues in 2019 in Turkey, patellar chondromalacia among soldiers with anterior knee pain and its prevalence and association with patellofemoral anomalies were investigated. In this study, 169 patients with patellar chondromalacia were examined. Patients with patellar chondromalacia showed significantly more patellar translation, a smaller patellofemoral angle, and a higher Insall-Salvati ratio compared to patients without patellar chondromalacia. However, none of the measurements were associated with the severity of cartilage damage. The final results of this study indicate that patellar chondromalacia is a common disorder

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among enlisted soldiers with anterior knee pain, and patellofemoral misalignment and patellar position are significant contributing factors in the development of patellar chondromalacia[16].

A study by Aysin and colleagues in Turkey in 2018 aimed to investigate whether there is an association between anterior knee pain and knee function with the stage of chondromalacia and patellar alignment in patients with anterior knee pain for more than one month and chondromalacia patellae (CMP) identified by MRI. The medical records of 38 patients who underwent knee MRI examination and were diagnosed with chondromalacia based on MRI were reviewed. Knee MRI images were evaluated by a radiologist for the stage of chondromalacia. Patients were divided into two groups: early-stage chondromalacia (stage 1-2) and advanced-stage chondromalacia (stage 3-4). Demographic data of patients (age, gender, and occupation), clinical features, physical examination findings, patellofemoral pain severity scale, Kujala patellofemoral scoring system, and functional index questionnaire scores were obtained from their medical records. The trochlear groove angle, groove depth, lateral patellofemoral angle, patellar translation, and Insall-Salvati index were measured using MRI images. According to the findings, the mean age of patients in the advanced-stage CMP group was higher compared to the early-stage CMP group (P=0.038). There was no statistically significant difference in other demographic information (P>0.05). MRI measurements did not show a difference between the groups (P>0.05). Patients in the advanced-stage CMP group had lower patellofemoral pain severity scores, lower Kujala patellofemoral scores, and lower functional index questionnaire scores compared to the early-stage CMP group. The differences were statistically significant. This study concluded that as the stage of chondromalacia progresses, symptom severity worsens, and knee function decreases. However, MRI measurements did not show a difference between patients with early-stage and advanced-stage CMP[17].

A study by Ozgen and colleagues in Turkey in 2016 aimed to evaluate a new MRI grading system for patellar chondromalacia using high-resolution images. Fat-Suppressed Proton Density (FS PD) images in the axial plane were examined with corresponding Transverse relaxation time (T2) mapping images. Two experienced observers, unaware of clinical data, evaluated 44 knee MR images and assessed patellar cartilage changes according to the proposed grading system. The inter-observer agreement was 0.80 (95% CI, 0.71–0.89). The intra-observer agreements were 0.83 (0.74-0.91, 95% CI(confidence interval)) for observer A and 0.79 (0.7-0.88, 95% CI) for observer B. This study concluded that MRI grading for patellar chondromalacia with corresponding images provides good inter-observer agreement, which may be useful in daily practice for reporting and comparing knee MRI examinations and also has the potential for more accurate clinical prognosis prediction[18].

In a study by Mehl and colleagues conducted in 2016 in Germany, the relationship between patellar cartilage defects and knee patellar structure was investigated using MRI. This study involved 43 patients (17 women, 26 men) with grade III and IV patellar cartilage defects confirmed by arthroscopy (case group) compared with a matched control group of patients with isolated traumatic anterior cruciate ligament tears without cartilage defects. The primary results of this study showed that in the case group, the cartilaginous groove angle was significantly higher, the distal bony groove angle was significantly higher, the distal groove depth was significantly lower, the CD index was significantly lower, and the IS index was significantly higher. The conclusion of this study indicated that patellar cartilage defects are associated with patellofemoral joint structure. Specifically, a flat and shallow trochlea, trochlear dysplasia, and patella alta play a role in the development of patellar cartilage defects, which should be considered when planning surgical cartilage repair in the patella[13].

In a study conducted by Lu and colleagues in 2016 in China, the abnormal patellar height based on the Insall-Salvati ratio and its association with patellar cartilage lesions was investigated in 1703 individuals. The findings of this study showed that the overall prevalence of patellar cartilage lesions was 38%. The prevalence was significantly higher in women than in men. Older age significantly increased the incidence of patellar cartilage lesions. Statistical analyses showed that the tendon-to-patella length ratio was significantly associated with patellar cartilage lesions. Additionally, patients with cartilage lesions showed significantly higher rates of patella alta and baja, and abnormal patellar height is significant in diagnosing cartilage lesions. The final conclusion of this study indicated that patients with patellar cartilage lesions had an increased tendon-to-patella length ratio. Abnormal patellar height is significantly associated with cartilage lesions and can be used as a potential diagnostic marker[19].

In a study by Lancourt and colleagues conducted in 1975 in France, the etiological role of patella alta and patella baja in patellar dislocation, chondromalacia, and tibial tubercle apophysitis was investigated. In this study, the Insall-Salvati method was used to assess patellar position in four groups of patients: normal patients and patients with patellar dislocation, patellar chondromalacia, and tibial tubercle apophysitis. The patella-to-tendon length ratio was 1.0 in normal patients, 0.8 in patients with dislocation, 0.86 in

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patients with chondromalacia, and 1.2 in patients with tibial tubercle apophysitis. They demonstrated that patella alta might be an important cause of patellar dislocation and patellar chondromalacia[20].

Method:

This cross-sectional study investigated the relationship between chondromalacia and patella position in MRI scans of patients referred to Imam Khomeini Hospital between 2021 and 2022. After obtaining necessary approvals and accessing hospital archives, 165 eligible patients were selected. Participants provided written informed consent after being informed about the study's purpose and methodology. The study was conducted in accordance with ethical guidelines from the Medical Ethics Committee of Jundishapur University of Ahvaz (IR.AJUMS.HGOLESTAN.REC.1402.153) and adhered to the Helsinki Declaration on research ethics, ensuring patient confidentiality.

Inclusion Criteria: Patients who underwent knee MRI for any reason and met the diagnostic criteria for chondromalacia.

Exclusion Criteria: Patients with incomplete information in their records or other diagnosed knee disorders.

MRI information, including the position of the patella (alta and baja) and knee deformity, was recorded by an experienced radiologist in a pre-designed data collection form. Additional required information was extracted by entering the patient code into the patient management system and included in the data collection form. This information included age, gender, weight, history of surgery, history of trauma, and clinical examination findings. The data were then entered into SPSS version 22 for analysis.

Qualitative data were reported as percentages and frequencies, and quantitative data were reported as Mean±SD (standard deviation). The Chi-square test was used to examine the relationship between qualitative variables. The t-test was used to compare two means, and (Analysis of Variance) ANOVA was used to compare more than two means. If the data distribution was non-normal, non-parametric equivalents of these tests were used. Regression models were employed to control for confounding factors. A significance level of 0.05 was considered. All data were analyzed using Statistical Package for the Social Sciences (SPSS) version 22.

Results:

Totally 165 patients were enrolled. 116 (70.3%) of the patients are women and 49 (29.7%) are men.

The average age is 34.70 years, with the youngest patient being 19 years old and the oldest 40 years old. The average weight of the patients is 68.90 kilograms, with the lowest weight being 50 kilograms and the highest weight 86 kilograms.

160 (97%) of the patients have no history of surgery, and 5 (3%) have a history of surgery. 75 (45.5%) have no history of trauma, and 90 (54.5%) have a history of trauma.

In Table 4, the distribution of patellar position shows that 114 individuals (69.1%) are classified as normal, and 51 individuals (30.9%) are classified as alta (table 1).

Table 1. Descriptive Statistics of Study Variables

Gender	Male	49 (29.7%)
	Female	116 (70.3%)
Age	34.7 ± 17.5	(19-40)
Weight	90.7 ± 68.9	(50-86)
Surgical History	No	160 (97%)
	Yes	5 (3%)
Trauma History	No	75 (45.5%)
	Yes	90 (54.5%)
Patellar Position	Normal	114 (69.1%)
	Alta	51 (30.9%)

The relationship between patellar position and gender has been examined using the chi-square test. As observed, there is no significant association between patellar position and gender.

The chi-square test was used to examine the association between history of surgery and gender. As seen, there is no significant relationship between history of surgery and gender.

The relationship between history of trauma and gender has been examined using the Chi-square test. As seen, there is no statistically significant relationship between history of trauma and gender (Table 2).

In table 3, linear regression was used to examine the relationship between types of patella position and independent variables age, gender, weight, history of surgery, and history of trauma. Among these variables,

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only history of trauma shows a statistically significant linear relationship with types of patella position.

Table 2. Relationship between History of Surgery, History of Trauma Variable and Patellar Position with gender

		Male	Female	P - Value
Patellar Position	Normal	37 (32.5)	77 (67.5)	0.27
	Alta	12 (23.5)	39 (76.5)	
History of Surgery	No	47 (29.4%)	113 (70.6%)	0.640
	Yes	2 (40%)	3 (60%)	
History of Trauma	No	37 (49.3%)	38 (50.7%)	<0.001
	Yes	12 (13.3%)	78 (86.7%)	

Table 3. Linear Regression of the Relationship between Types of Patella Position and Independent Variables Age, Gender, Weight, History of Surgery, History of Trauma

Variable	B	Standard Deviation	Beta Coefficient	t	P-value
Constant	1.63	0.33		4.81	0
Age	0.01	0.007	0.15	-1.93	0.05
Gender	0.004	0.09	0.003	-0.03	0.97
Weight	0.005	0.006	0.08	0.90	0.36
History of Surgery	0.23	0.20	0.08	1.15	0.25
History of Trauma	0.36	0.07	0.39	-4.96	0.001

Discussion:

This study aimed to investigate the relationship between chondromalacia and patellar position in MRI scans of patients who visited Imam Khomeini Hospital during the years 1400-1401 (2021-2022). According to the results, 116 (70.3%) of the patients were female and 49 (29.7%) were male. Among these patients, 160 (97%) had no history of surgery, while 5 (3%) did. Additionally, 75 (45.5%) had no history of trauma. The distribution of patellar position showed that 114 (69.1%) had a normal position and 51 (30.9%) had patella alta. Using the Chi-square test, no significant relationship was found between patellar position and gender or between surgical history and gender. However, using linear regression to examine the relationship between patellar position and independent variables such as age, gender, weight, surgical history, and trauma history, only trauma history showed a significant linear relationship with different patellar positions.

Cartilage damage to the patella may result from morphological changes or anatomical misalignment. This can lead to joint surface issues and increased mechanical load on the normal joint surface. Therefore, evaluating the morphological characteristics of the patellofemoral joint plays an important role in diagnosing and treating chondromalacia [17].

Although tangential images during flexion are recommended for diagnosis, confirming the diagnosis based on these radiographs is difficult. Existing measurements do not adequately reflect the true alignment of the patella, and studies have shown inconsistent results regarding normal congruence angle measurements. Arthroscopy is a reliable diagnostic method; however, surgical treatment for CMP is indicated in less than 10% of patients. MRI is the imaging method of choice for non-invasive diagnosis of CMP[21].

Although studies support the use of MRI for diagnosing patellofemoral joint abnormalities, there are few studies that clearly define and confirm normal and pathological MRI findings in clinical practice. Additionally, only a few studies examine chondromalacia and patellofemoral joint morphology using MRI (45). Rubenstein and colleagues stated that routine clinical MRI images failed to show early degenerative changes in the joint cartilage. Diagnosing small fissure defects in superficial cartilage damage without arthrography is difficult. Studies have shown that routine MRI sequences are highly accurate in diagnosing late-stage cartilage lesions[22].

Yang and colleagues examined 111 patients with anterior knee pain and chronic patellofemoral cartilage lesions who underwent arthroscopy. They reported that patellofemoral cartilage lesions were more prevalent when the lateral joint surface was dominant. Additionally, regarding femoral trochlear morphology, the depth of the groove and relative groove depth were significantly associated with patellofemoral cartilage lesions. Evidence suggests that a femoral trochlea with a shallower groove increases the risk of patellar cartilage damage[23].

One study showed a relationship between increased groove angle and increased cartilage damage in medial and lateral cartilage in patients with osteoarthritis. Researchers concluded that a wider groove accelerates

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cartilage loss by increasing pressure on the patellofemoral joint surface [24].

Tuna and colleagues investigated the relationship between patellofemoral misalignment and the degree of patellar chondromalacia. They found significant differences between mild and severe chondromalacia groups regarding groove angles and trochlear depth [21].

Patella alta, determined using the Insall-Salvati index, is considered a risk factor for CMP [25]. Yang and colleagues compared patients with anterior knee pain and chronic patellofemoral cartilage lesions who underwent arthroscopy with patients who had anterior knee pain but isolated meniscal tears. They observed a lower frequency of patella alta and baja in the lesion group, although the Insall-Salvati index did not significantly differ between the two groups. They concluded that despite changes, these parameters do not affect patellofemoral joint damage [23].

Kaur and colleagues showed that as chondromalacia progresses, symptom severity worsens and knee function declines. However, MRI measurement values did not differ between early and advanced CMP patients [26].

In a 2020 study by Ozel in Turkey, the relationship between early chondromalacia and patellar position was examined in patients aged 18-40 with advanced chondromalacia. Findings indicated that both patella alta and baja are predisposing factors for chondromalacia. The modified Insall-Salvati index was the best measurement for defining patella alta. The final conclusion stated that both patella alta and baja predispose individuals to chondromalacia. Due to its rarity, patella baja is often not mentioned as a predisposing factor. The modified Insall-Salvati ratio was the best index for alta, aligning more closely with other indices. BP could not be optimally calculated due to the difficulty in determining the location of the tibial plateau, as it is a complex three-dimensional structure [12].

Conclusion:

The findings of this study indicated that patellar position is recognized as a predisposing factor for chondromalacia. However, our study has several limitations. Firstly, there are no established normal values or specific methods for MRI measurements. Secondly, the stage of chondromalacia was assessed retrospectively based on MRI findings rather than arthroscopy. Thirdly, no evaluation was conducted on healthy individuals. To determine normal measurement values and their correlation with clinical findings, large-scale prospective studies with control groups are needed.

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Authors Contributions:

The author contributed to the data analysis. Drafting, revising and approving the article, responsible for all aspects of this work.

Ethical Consideration:

The research data and literature have not been copied from any works author upon reasonable request

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