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Investigating the Relationship between Patellar Subluxation and Patellar Cartilage Damage in Magnetic Resonance Imaging of patients

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Abstract

Background: Patellar subluxations can lead to cartilage defects, and pathological lesions of the patellar cartilage in recurrent patellar dislocation are known as patellar chondromalacia. However, the cause of patellar cartilage lesions in recurrent patellar dislocation (RPD) is not well understood. This study aimed to investigate the association between patellar subluxation and patellar cartilage injury on Magnetic Resonance Imaging (MRI) in patients referred to Imam Khomeini Hospital during the year 2021-2022. **Method:** In this cross-sectional study, patients diagnosed with patellar subluxation on MRI were included. Patients with incomplete medical records and other diagnosed patellar disorders were excluded from the study. **Results:** Our study results showed no significant relationship between patellar cartilage injury and gender. There was also no significant association between history of surgery and history of trauma. However, significant differences were found between age, weight, and patellar cartilage injury. Further studies with larger sample sizes are recommended to investigate the relationship between patellar subluxation and patellar cartilage injury on MRI in patients. **Conclusion:** The findings of this study can contribute to reducing complications and improving outcomes in patients with patellar subluxation. Additionally, it can prevent unnecessary diagnostic and therapeutic costs and enhance the quality of life for these patients.

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Introduction:

Lateral patellar dislocation (LPD) is a relatively common injury, especially among active young individuals, contributing to an estimated 2 to 3% of knee osteoarthritis cases and potentially resulting in significant impairment and functional limitations [1-3]. Richerand in 1802 was the first to associate symptoms of patellar luxation with anatomical abnormalities, particularly related to trochlear dysplasia[4]. Since then, various anatomical factors such as trochlear dysplasia, patellar height, patellar tilt, and patella alta have been associated with lateral patellar dislocation. Recurrent dislocations may lead to joint surface damage, causing cartilaginous defects or osteochondral injuries, resulting in persistent pain, functional

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impairment of the knee, and diminished quality of life for patients [5-8].

Despite numerous investigations and studies, there remains a debate regarding the prevalence, extent, and location of cartilage lesions[9-11]. Previous studies have reported that many patients with recurrent patellofemoral instability exhibit chondral defects and osteochondral fractures in the medial patellar facet and lateral trochlea; however, evidence regarding the frequency, location, and severity of cartilage damage in patients with recurrent patellofemoral instability is limited[12-17].

Studies have indicated that patellar dislocations contribute to cartilaginous defects; pathological cartilage lesions in recurrent patellar dislocation are termed patellar chondromalacia, yet the exact cause of cartilage lesions in recurrent patellar dislocation (RPD) remains poorly understood[18].

So far, various classification systems have been established by different individuals for patellar cartilage lesions. According to textbooks, patellar cartilage lesions are classified based on macroscopic observations as follows: Grade 1: softening, Grade 2: fissuring, Grade 3: fibrillation, and Grade 4: erosion. Grades 2 to 4 lesions are categorized as chondromalacia[19].

The exact occurrence of cartilaginous defects following patellar dislocation remains unclear. Several studies have demonstrated up to 96% incidence of cartilage injuries after the first patellar dislocation [20, 21]. Guerrero et al. assessed post-lateral patellar dislocation injuries in 195 patients and found a 49% rate of cartilage damage on MRI [11]. Nomura et al. evaluated the cartilage status of 70 patients after patellar dislocation arthroscopically and discovered that 96% had patellar cartilage damage: fissures were observed in 75%, while fibrillation or erosion was seen in 77% (54 knees out of 70)[22]. Sanders et al. reported 40% prevalence of patellar cartilage injury: 70% involved full-thickness cartilage defects including subchondral bone, and 30% involved bone injury within the subchondral bone[23].

As mentioned above, numerous reports exist regarding macroscopic or arthroscopic findings of patellar chondromalacia, with different individuals categorizing these cartilage defects. Outerbridge et al. examined 196 patients aged 12 to 69 undergoing internal meniscectomy and classified patellar cartilage lesions into four grades [24]. Casscells also studied cartilage changes in 300 knees of individuals with an average age of 70 years and classified patellar cartilage changes into four grades based on lesion severity and extent[25]. Ogilvie-Harris and Jackson investigated 319 patients with patellar chondromalacia and chronic patellofemoral pain arthroscopically, dividing patients into four etiological groups: patellar maltracking, patellar instability, post-traumatic chondromalacia, and idiopathic chondromalacia[25].

One of the significant causes of knee joint subluxations is patellofemoral instability. Susceptible patoanatomic factors can be found in most patients with patellar cartilage defects, which, if left untreated, can lead to persistent pain, limiting daily activities, and potentially causing early-onset arthritis in the long term [26-28]. The medial patellofemoral ligament is the most important restraint against lateral patellar displacement within the first 30 degrees of knee flexion. Therefore, untreated tears of the medial patellofemoral ligament can increase joint instability and consequently the risk of recurrent dislocation[7, 29, 30].

Considering the above issues and the importance of early and appropriate diagnosis and treatment of knee deformities and their impact on patellar cartilage injuries, and given the lack of similar studies in Iran, this study aimed to investigate the relationship between patellar subluxation and patellar cartilage injury. The results of this study could prevent excessive diagnostic and therapeutic costs and improve patients' quality of life.

"In a study conducted in 2020 by Sirik and colleagues to investigate the relationship between meniscal volume and meniscal chondromalacia using MRI of the knee, a total of 162 patients who underwent knee MRI between January 2017 and May 2017 due to knee pain were included in this study. Of these, 111 cases had meniscal chondromalacia and 51 were healthy individuals. The volume of the meniscus in all cases was analyzed using semi-automated software. The cases were classified according to the Outerbridge classification based on the degree of chondromalacia. The statistical analysis included examining the relationship between meniscal volume, presence of chondromalacia, cartilage thickness, age, and gender. Out of 162 cases, 67 (41.4%) were male and 95 (58.6%) were female. The average age of the patients was 44 years. The meniscal volume ranged from a minimum of 12.24 cm^3 to a maximum of 39.44 cm^3, with a median of 21.4 cm^3, and was higher in patients with chondromalacia (P = 0.026). In patients with meniscal chondromalacia, the thickness of the cartilage was lower in the medial compartment. There was a weak positive correlation between the degree of chondromalacia and meniscal volume (P = 0.031). The results of this study showed that meniscal chondromalacia is significantly associated with meniscal volume, being one of the important causes of chronic anterior knee pain. The internal cartilage of the meniscus was thinner in cases with meniscal chondromalacia. Although the average age of

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individuals with chondromalacia was higher than those without chondromalacia, there was no significant difference between males and females [31]."

"A study conducted in 2017 by Salonen and colleagues aimed to investigate the relationship between traumatic lateral meniscal tear for the first time and cartilage degeneration. Twenty patients (average age, 25 years) who experienced traumatic lateral meniscal tears without previous signs of meniscal instability were initially scanned using MRI. A follow-up MRI 3-T scan was conducted on average 8 years after the initial traumatic lateral meniscal tear. Knee symptoms and osteoarthritis outcomes were also evaluated. In the initial MRI, patellofemoral cartilage damage was observed in 14 out of 20 patients (70%). More lesions (14/15) were seen in the meniscal cartilage, especially in the inner part. In the follow-up MRI, patellofemoral cartilage degeneration was observable in all patients. Central meniscus tears, especially over the follow-up period, were susceptible to cartilage degeneration (P = 0.005). Half of the patients (10/20) had grade 3-4 cartilage lesions in the knee joint in the follow-up MRI. In the initial MRI, only 1 patient showed tibiofemoral joint cartilage lesions, while during follow-up, 10 out of 20 patients exhibited tibiofemoral cartilage lesions. Most of these lesions were clinically considered insignificant. Among the 14 patients (36%) with meniscal cartilage damage, 5 reported instability following knee meniscal joint, but this was not associated with significant cartilage degeneration in comparison to patients without recurrent displacement. While it is known that recurrent lateral meniscal tears lead to a degenerative process, it appears that a traumatic lateral meniscal tear that occurs for the first time or rarely may also be associated with gradual cartilage degeneration. Traumatic lateral meniscal tear may lead to gradual cartilage degeneration in the knee meniscal joint and may lead to the development of general knee arthritis. However, instability symptoms of the meniscal-femoral joint did not correlate with severity and intensity[32]."

"In a study conducted by Nomura and colleagues in 2004, they investigated patellar cartilage lesions in recurrent patellar dislocation. Findings of this study indicated that 96% of knee cases had patellar articular cartilage lesions, while only 3% showed no changes. Fissuring was observed in 53 knees (76%). Essentially, there were two types of fissures: multiple longitudinal fissures and marginal/radial fissures. Fibrillation and/or erosion were observed in 77% of cases. Among these, 40 knees had fissuring and 14 knees did not. The primary location of fibrillation and/or erosion was the inner part. The study concluded that patellar cartilage lesions are very common in cases of recurrent patellar dislocation. Fissuring was mainly observed in the central part, while fibrillation and/or erosion were predominantly seen in the inner face[22].

In a study conducted by Nomura and colleagues in Japan in 2003, they examined cartilage injuries and osteochondral injuries associated with acute patellar dislocation. Findings of the study showed that 37 knees (95%) had patellofemoral articular cartilage damage, while 2 knees (5%) did not have cartilage injuries. In all 37 knees, patellar articular cartilage damage was observed. Cartilage injuries were classified into 3 groups: cracks alone (9 knees), cartilage defects due to bone or cartilage fracture (7 knees), and cartilage defects due to bone or cartilage fracture accompanied by cracks (21 knees). The primary site of osteochondral fractures was the inner face, and the primary site of cracks was the central part. Twelve knees (31%) had lateral femoral condyle cartilage injuries. The study concluded that articular cartilage injuries, especially in the patella, are common occurrences after acute patellar dislocation[20]."

In a study conducted by Prince and colleagues in 2015 in the United States, they investigated the treatment of patellofemoral cartilage lesions in active young patients. Early surgical intervention often appears appropriate for traumatic injuries that lead to osteochondral damage, including acute patellar dislocation. For chronic lesions, initial treatment includes non-surgical measures, with surgery reserved for patients with persistent symptoms. A comprehensive medical history, physical examination, and imaging are crucial for selecting the optimal surgical approach[33].

In a study conducted by Migliorini and colleagues in 2022 in Germany, they conducted a review study to investigate cartilage injuries in patients with recurrent patellar dislocation. The mean age of the enrolled patients was 6.5±21.2 years. The results of this study showed that 84.8% of patients suffering from recurrent patellar dislocations exhibited patellar cartilage defects: medial facet (34.9%), lateral facet (34.8%), and lateral facet (17%). 27.8% of patients showed trochlear cartilage injuries. The conclusion indicated that cartilage lesions in the medial facet and patellar crest are the most common in patients with recurrent patellofemoral instability[34].

In a study conducted by Migliorini and colleagues in 2021 in Germany, they conducted a review study to investigate cartilage injuries and soft tissue associated with acute patellar dislocation. The mean age was 7.3 ± 21.6 years. The findings of the study showed that 28% of patients experiencing their first patellar dislocation exhibited internal patellofemoral ligament tears on MRI. Forty-eight percent of these tears were on the patellar side, 34% at the femoral attachment site, and 18% in the midportion. Eighty-five percent of patients

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showed signs of patellar cartilage injury on MRI, and trochlear cartilage injury was evident in 47% of patients. Loose bodies within the joint were observed in 11.5% of patients. Arthroscopically, the medial facet and patellar crest showed more cartilage lesions compared to the lateral facet and femoral trochlea[8].

In a study conducted by Vollnberg and colleagues in 2012 in Germany, they investigated the prevalence of cartilage lesions and early osteoarthritis in patients with patellar dislocation. They divided patients into three groups: acute dislocation (Group A), recurrent (Group B), and chronic (Group C). The results of this study showed that the prevalence of cartilage lesions in Groups A, B, and C were 71%, 82%, and 97%, respectively. Most lesions were located on the central patella in Groups A and B (central 69% and 78%; medial 56% and 47%; lateral 31% and 42%), whereas Group C showed involvement in all areas (73%, 61%, and 67%). Mild osteoarthritis (OA) was present in 14% of Group A and 64% of Group B. In Group C, 62% had mild OA and 18% had moderate OA. The size of cartilage defects and the prevalence of OA were correlated with the number of dislocations. This study demonstrated that cartilage lesions and early osteoarthritis are common after patellar dislocation and appear to increase with the frequency of dislocations[35].

Method:

Study Population, Sampling, and Study Design:

This investigation is a cross-sectional study conducted to examine the association between patellar subluxation and patellar cartilage injury on MRI in patients referred to Imam Khomeini Hospital between the years 2021-2022. After the study plan was approved by the research group and the deputy for research, all patient codes who underwent knee MRI during the specified period for any reason were retrieved from the hospital archive. Patients meeting the diagnostic criteria for patellar subluxation were included in the study. This study was conducted after approval from the Research Council and obtaining ethical code (IR.AJUMS.HGOLESTAN.REC.1402.154) from the Ethics Committee of Jundishapur University of Medical Sciences, Ahvaz. Additionally, ethical statements from the Helsinki Declaration and principles of patient confidentiality were observed.

Inclusion Criteria: Patients diagnosed with patellar subluxation on their MRI and having complete medical records.

Exclusion Criteria: Incomplete patient file information and other diagnosed patellar disorders.

This is a cross-sectional study conducted to investigate the association between patellar subluxation and patellar cartilage injury on MRI in patients referred to Imam Khomeini Hospital between the years 1400 to 1401. After the study plan was approved by the research group and the deputy for research, all patient codes who underwent knee MRI during the specified period for any reason were retrieved from the hospital archive. Patients meeting the inclusion criteria, which included those diagnosed with patellar subluxation on MRI, were included. Patients with incomplete medical records and other diagnosed patellar disorders were excluded from the study. Based on the patient code, access to MRI findings was possible through the PACS (Picture archiving and communication) system. The information obtained from MRI, including patellar cartilage injury and knee deformities, was recorded in a data collection form designed in advance and entered into the system. Other necessary information, such as age, gender, weight, surgical history, trauma history, and clinical examination findings, was extracted by entering the patient code into the patient management system and entered into the data collection form.

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. The data collection tool in this study was a pre-designed data collection form, the file of which was attached at the end of the proposal and submitted.

The data collection tool in this study was a data collection form that included information such as age, gender, weight, surgical history, trauma history, knee deformities, and patellar cartilage injury.

Results:

Totally 180 patients were enrolled. In this chapter, both descriptive and inferential statistics were used for analyzing the collected data. The hypothesis of this study aims to investigate the relationship between patellar subluxation and patellar cartilage injury detected on MRI among patients visiting Imam Khomeini Hospital in the years 1400-1401. The detailed description is as follows:

The frequency distribution of the gender variable is presented. As observed, 50% of the patients are female and 50% are male. The average age is 40.10 years, with the youngest patient being 15 years old and the oldest

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being 72 years old. The average weight of the patients was 68.68 kilograms, with the lowest weight being 32 kilograms and the highest weight being 90 kilograms. None of the patients have a surgical history, 78 (43.3%) have no trauma history, and 102 (56.7%) have a history of trauma. The frequency distribution of patellar cartilage damage shows that 54 (30%) individuals do not have damage, and 126 (70%) individuals have damage (Table 1).

Table 1. Descriptive Statistics of Study Variables

Gender	Male	90 (50%)
	Female	90 (50%)
Age	40.10±12.22	(15-72)
Weight	68.68± 12.09	(32-90)
Surgical History	No	180 (100%)
	Yes	0 (0%)
Trauma History	No	78(43.3%)
	Yes	102(56.7%)
Patellar cartilage damage	No	54 (30%)
	Yes	126 (70%)

Table 2. Association between patellar cartilage damage and gender and Trauma History

		Patellar Cartilage Damage		P - Value
		No	Yes	
Gender	Male	31(57.4%)	59(46.8%)	0.19
	Female	23(42.6%)	67(53.2%)	
Trauma History	No	28 (51.9%)	50 (39.7%)	0.13
	Yes	26 (48.1%)	76 (60.3%)	

Table 3. Linear regression of different positions of patella and independent variables age, gender, weight, history of surgery, history of trauma

Variable	B	Standard Deviation	Beta Coefficient	Degrees of Freedom	P-value
Intercept	0.049	0.031	2.562	1	0.10
Age	-0.612	0.367	2.778	1	0.09
Gender	0.033	0.029	1.311	1	0.25
Weight	0.933	0.378	6.100	1	0.01
History of Trauma	-2.770	1.260	2.562	1	0.02

Table 4. Relationship between age, weight, and patellar cartilage damage

Variable	Patellar Cartilage Damage	Mean ± Standard Deviation	P-value
Age	No	10.67 ± 33.87	<0.001
	Yes	11.90 ± 42.77	
Weight	No	12.44 ± 62.70	<0.001
	Yes	11.03 ± 71.24	

The relationship between patellar cartilage damage and gender is examined using the chi-square test. It can be seen that there is no significant association between patellar cartilage damage and gender.

The relationship between patellar cartilage damage and history of surgery is examined using the chi-square test. It can be seen that there is no significant association between history of surgery and patellar cartilage damage (Table 2).

Linear regression is used to examine the relationship between different positions of the patella and independent variables including age, gender, weight, and history of trauma. Among these variables, different positions of the patella show a significant linear relationship with weight and history of trauma (Table 3).

The relationship between age, weight, and patellar cartilage damage is examined using the Wilcoxon test. It can be seen that there is a significant difference between age, weight, and patellar cartilage damage.

Discussion:

Patellar cartilage damage may occur acutely due to direct impact, but it can also manifest chronically due to microtrauma. There is limited research on whether patellar subluxation may predispose individuals to

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chondromalacia patellae. However, most studies have focused on patellofemoral joint, which has a more complex structure. The effects of patellar alignment disorders, trochlear groove and trochlear dysplasia, patellar tilt, and the distance between the tibial tuberosity and trochlear groove have been investigated[36].

This study aimed to examine the association between patellar subluxation and patellar cartilage damage on MRI in patients referred to Imam Khomeini Hospital during the years 1400-1401. The study results showed no significant association between patellar cartilage damage and gender. There was also no significant association between history of surgery and trauma. However, different types of patellar positions showed a significant linear relationship with independent variables such as age, gender, weight, and history of trauma. Significant differences were found between age, weight, and patellar cartilage damage.

In the study by Salonen et al., which aimed to investigate the relationship between patellar dislocation due to trauma for the first time and cartilage degeneration, initial MRI showed patellofemoral cartilage damage in 14 out of 20 patients (70%). No significant association was observed between history of surgery and trauma. These results are consistent with the findings of the current study[32].

In the study by Sirik et al., the association between patellar volume and chondromalacia patellae was examined using MRI of the knee. A total of 162 patients undergoing MRI due to knee pain were included in this study, with 111 cases of chondromalacia patellae and 51 healthy individuals. Based on correlation analysis between patellar volume, presence of chondromalacia, cartilage thickness, age, and gender, a significant association was found. The study mentioned that although the average age of individuals with chondromalacia was higher than those without, no significant difference was observed between males and females affected by chondromalacia patellae in this study [31].

Besides joint fusion, the most common abnormalities were bone marrow edema (88%) and cartilage damage (84%). While cartilage damage can have long-term consequences and accelerate arthritis, bone marrow edema can be considered as a footprint of the injury mechanism.

In the study by Sirik et al., patellar volume was higher in patients with patellar chondromalacia. The mean thickness of the medial patellar cartilage in patients with chondromalacia patellae was lower. The risk of chondromalacia increased with age. Although slightly higher in women, no significant difference was observed between men and women with patellar chondromalacia in this study. Additionally, there was a weak but significant relationship between patellar volume and the degree of chondromalacia, but no strong relationship was found. This study found significant age and weight differences with patellar cartilage damage, contradicting our study findings.[31]

The limitations of this study include not evaluating the relationship between patellar volume and Body Mass Index (BMI) cases and the loss of data resulting from routine MR section thickness measurement, both due to a retrospective design. Further studies can plan more detailed evaluations of chondromalacia based on BMI using thin-section MRI and optimal patellar volume calculation. The statistical age difference between the case and control groups in this study may bias the potential effects of age on other parameters. Moreover, the significant statistical difference in patellar volume between men and women may lead to bias. Therefore, further studies are needed with more homogeneous populations in study and control groups.

Conclusion:

Our study results showed no significant association between patellar cartilage damage and gender. There was no significant association between history of surgery and trauma. Significant differences were found between age, weight, and patellar cartilage damage. Further studies with larger sample sizes are needed to investigate the association between patellar subluxation and patellar cartilage damage on MRI in patients.

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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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