



Effects of body mass index, infrapatellar fat pad volume and age on patellar cartilage defect

Semra DURAN, Ertugrul AKSAHIN, Onur KOCADAL, Cem Nuri AKTEKIN, Onur HAPA, Zeynep BIYIKLI GENCTURK

From Ankara Training and Research Hospital, Ankara, Turkey

The aim of this study was to evaluate the associations between patellar cartilage defects and body mass index (BMI), infrapatellar fat pad (IPFP) volume and age. 100 patients who met the inclusion criteria and were aged 18 to 60, were evaluated retrospectively. For detecting and measuring patellar cartilage defects, axial sequences were used and sagittal sequences were used to evaluate IPFP volumes. In total, 40 patients had patellar cartilage defects. In this group, age and BMI were higher in both sexes when compared with the controls ($p < 0.05$). The IPFP volume was lower in the group with the patellar cartilage defect when compared with the control group ($p < 0.05$). The IPFP volume was statistically significantly lower in women ($p < 0.05$). Patellar cartilage defect was found to be related to age and BMI. In women, the decrease in IPFP volume seems to be one of the causative factors for patellar cartilage defect.

Key words : obesity ; adipocyte, cartilage defects ; infrapatellar fat pad ; magnetic resonance imaging.

INTRODUCTION

Chondromalacia patella is the cartilage degeneration of the patella, which spans a wide spectrum from the softening and fissuration of the hyaline cartilage to bone erosion and full-thickness articular cartilage defect (15). Even though it can be seen in adolescents and younger adults, it is common in older adults (7,12,14,15,18). Magnetic resonance imaging (MRI) could help in detecting structural changes of the cartilage in early phases and it has approximately 90% specificity and sensitivity (8,12,14,17,18).

Adipose tissue-related obesity is a strong risk factor for tibiofemoral and patellofemoral joint osteoarthritis (2,4,8,10,20). There are only a few studies analyzing the association between the amount and distribution of overall body adipose tissue and patellofemoral joint osteoarthritis (8,9,20). To the best of our knowledge, there is no study analyzing the association between infrapatellar fat pad volume and patellar cartilage defects.

In the current study, the aim was to analyze the relationships between infrapatellar fat pad (IPFP) volume, age, body mass index (BMI) and prevalent patellar cartilage defect. We hypothesized that there

-
- Semra Duran, MD.
Department of Radiology, Ankara Numune Training and Research Hospital, Ankara, Turkey.
 - Ertugrul Aksahin, Assoc Prof.
Department of Orthopedics and Traumatology, Ankara Training and Research Hospital, Ankara, Turkey.
 - Onur Kocadal, MD.
 - Cem Nuri Aktekin, Assoc Prof.
Department of Orthopedics and Traumatology, Ankara Training and Research Hospital, Ankara, Turkey.
 - Onur Hapa, MD.
Department of Orthopedic Surgery, Dokuz Eylul University, Izmir, Turkey.
 - Zeynep Biyikli Gencturk, MD.
Department of Biostatistics, Ankara University Faculty of Medicine, Ankara, Turkey.
- Correspondence : Onur Kocadal, Ankara Training and Research Hospital, Ulucanlar, Ankara, Turkey.
E-mail : onurkocadal@gmail.com
© 2015, Acta Orthopædica Belgica.
-

*No benefits or funds were received in support of this study.
The authors report no conflict of interests.*

are positive associations between age, BMI, IPFP and prevalent patellar cartilage defect.

MATERIAL AND METHODS

160 patients who had undergone knee MRI analyses for any indication between September 2012 and March 2013 were evaluated retrospectively. Patients who had undergone any knee surgery ($n = 20$), those with space occupying lesions in the IPFP ($n = 7$), those with a history of acute trauma ($n = 10$), patients younger than 18 and older than 60 years old ($n = 20$) and patients with a history of radiotherapy in the knee region ($n = 3$) were excluded. Thus, a total of 100 patients were involved in the study. Patients with normal cartilage were categorized in Group I and patients with a cartilage defect graded as 3 or 4 were put in Group II.

Anthropometric measures : BMI was calculated by dividing weight in kg by the square of the height in meters (kg/m^2).

Magnetic Resonance Imaging : The MR images (Optima, GE Medical System, Milwaukee, Wisconsin, USA) of the patients were taken with a 1.5-T unit using extremity coil. A standardized MRI examination protocol was used and the following five sequences were performed for each patient.

1. Sagittal T1 weighted (W) fast spin echo (FSE) : repetition of time (TR) : 508 ms, echo of time (TE) : 10.34 ms, thickness : 4 mm, matrix : 288×224 , field of view (FOV) : 18 cm.
2. Sagittal 3D T2W Cube FSE : TR : 1500 ms TE : 124.4 ms thickness : 1 mm matrix : 224×224 FOV : 20 cm.
3. Coronal T1W FSE : TR : 645 ms, TE : 15.46 ms, thickness : 4 mm, matrix : 288×224 , FOV : 20 cm.
4. Coronal fat-suppressed proton density weighted (PDW) FSE : TR : 2323 ms, TE : 45.48 ms, thickness : 4 mm, matrix : 288×224 , FOV : 20 m.
5. Axial fat-suppressed PDW FSE : TR : 2742 ms, TE : 39.8 ms, thickness : 3 mm, matrix : 288×224 , FOV : 18 cm.

To evaluate the presence of a patellar cartilage defect and its size, we used axial fat-suppressed PDW FSE, and sagittal 3D T2W Cube FSE sequences were used to measure the IPFP volume.

Assessment of patellar cartilage defects : Patellar cartilage defects (0-4 scale) were graded with MRI using the following classification system ; grade 0 : normal cartilage ; grade 1 : focal blistering and intra-cartilaginous abnormal signal intensity area with an intact surface and

bottom ; grade 2 : irregularities on the surface or bottom and loss of thickness $< 50\%$; grade 3 : deep ulceration with loss of thickness $> 50\%$; grade 4 : full-thickness cartilage wear with exposure of subchondral bone (8,9). A patellar cartilage defect was based on the presence of an irregularity on the cartilage surface with loss of cartilage thickness on at least two consecutive slices. The cartilage defects were re-graded 1 month later by the same observer (S.D.), and the average scores of cartilage defects in the patellar compartment (range 0-4) were used in the study. A prevalent cartilage defect was defined as a cartilage defect score ≥ 3 at any site within the patellofemoral compartment. The ICC (expressed as intra-class correlation coefficient) for intra-observer reliability was 0.95 for cartilage defects.

Volumetric analysis of the fat pad using MR images : Infrapatellar fat pad volume was determined with MR images using OsiriX Imaging Software (Osirix Imaging Software, Osirix, Geneva, Switzerland) an independent Workstation (3,12) (Fig. 1). A single observer (OK), who was blinded with respect to all subject information, did all of the image analysis. Intra-observer reliability for fat pad volume (expressed as ICC) was assessed in 40 randomly selected MRIs and was 0.95.

Statistical analysis : Statistical analyses were evaluated using the SPSS 15.0 (SPSS Inc. Chicago, IL) program. A chi-square test was used to compare groups (group I and II) in terms of gender. Group comparisons for age, BMI, and IPFP volume were made with the Mann-Whitney U test. We tested the correlation between BMI and IPFP volume with Spearman's correlation test. A covariance analysis was used to test the association between groups' gender and IPFP volumes controlling for age and BMI. The independent samples t test was used to test the differences between sexes in terms of age, BMI, IPFP volume in each group. A p-value of less than 0.05 was considered statistically significant.

RESULTS

There were 60 patients (40 women and 20 men) in Group I and 40 patients (28 women and 12 men) in Group II. The demographics of the patients are given in Table I. Age, BMI, and IPFP volume comparisons by group are given in Table II.

IPFP volume was lower in the patients with cartilage defect than in the controls ($p < 0.05$). There was a significant decrease in IPFP volumes in females, while no difference was detected in men ($p > 0.05$). The patients with cartilage defect were significantly

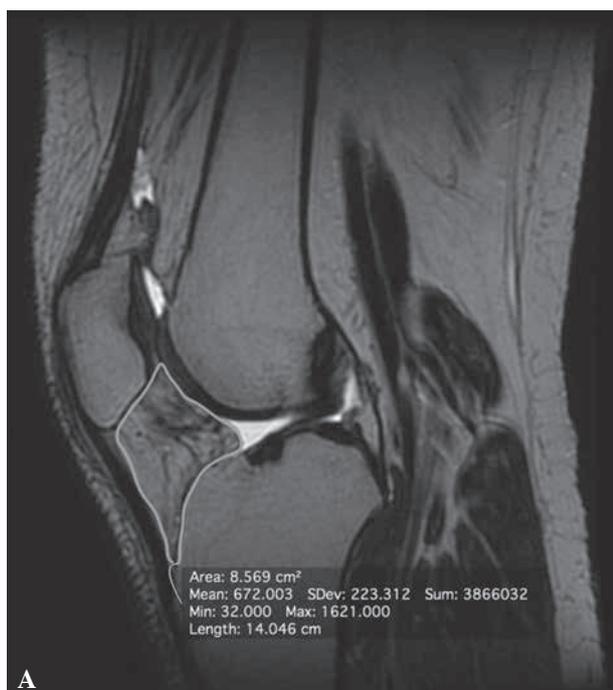


Fig. 1A. — Determination of the boundaries of the IPFP

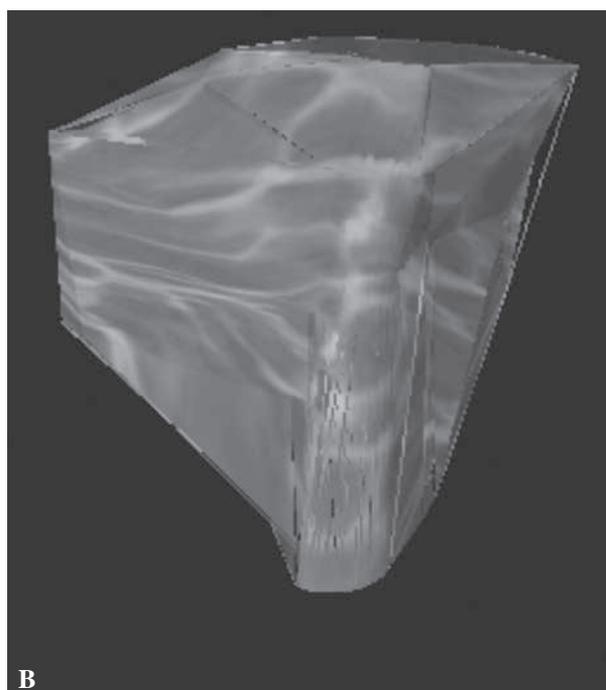


Fig. 1B. — Measurement of the IPFP volume

(IPFP : Infrapatellar fat pad)

Table I. — Characteristic of the study population (n=100)

Characteristic	Value		
	Female	Male	Total
Age(year)	43.0 ± 10.1	43.9 ± 8.9	43.3 ± 12.9
Sex (%)	68	32	100
Weight (kg)	73.8 ± 4.5	81.0 ± 3.4	76.1 ± 14.4
BMI (kg/m ²)	27.20 ± 4.5	27.5 ± 3.2	27.3 ± 4.5
IPFP volume (cm ³)	16.63 ± 5.1	18.8 ± 5.0	17.3 ± 6.0

Values are expressed as mean ± standard deviation ; BMI = body mass index ; IPFP = infrapatellar fat pad.

Table II. — Descriptive analyses of age, weight, BMI and IPFP volume by groups

	Group I	Group II	p-value
Age (year)	37.5 ± 10.4	56 ± 9.2	p < 0,05
Weight (kg)	74.0 ± 14	77.5 ± 14.6	p < 0,05
BMI(kg/m ²)	26 ± 4.0	29 ± 4.3	p < 0,05
IPFP volume(cm ³)	17 ± 6.4	14.5 ± 4.4	p < 0,05

Values are expressed as mean ± standard deviation BMI = body mass index ; IPFP = infrapatellar fat pad.

Table III. — Descriptive analyses of age, BMI and IPFP volume by sex

	Group I		Group II		p-value
	female	male	female	male	
Age (year)	35.8 ± 10.7	38.1 ± 9.7	53.2 ± 9.7	53.6 ± 8.1	p < 0,05
BMI (kg/m ²)	25;4 ± 4.5	26.4 ± 2.8	29.6 ± 4.6	29.5 ± 4.0	p < 0,05
IPFP volume (cm ³)	18.8 ± 6.5*	19.4 ± 6.5*	13.4 ± 3.7*	17.8 ± 4.5*	

Values are expressed as mean ± standard deviation BMI= body mass index ; IPFP= infrapatellar fat pad.

*Significant difference between females vs. males (P < 0,05).

Group I : Patients without articular cartilage defect ; Group II : Patients with articular cartilage defect.

older than the controls (p < 0.05). BMI was higher in Group II for both genders when compared to the controls (p < 0.05). Age, BMI and IPFP volumes by gender and group are given in Table III.

We did not detect any difference between BMI and IPFP volumes in the groups. There were no statistical differences in terms of Group I and Group II by gender (p > 0.05).

There was no difference between the groups in terms of IPFP volumes when analyses were controlled for age and BMI (p > 0.05). However, the gender difference remained significant (p < 0.05). Overall, gender seems to be an independent factor for IPFP volume.

DISCUSSION

The main finding of the current study was the decrease in IPFP volume in the patients with cartilage defect. To the best of our knowledge, this is the first study emphasizing the association between IPFP volume and patellar cartilage defect. Another finding of this study is the positive association between age, BMI and the cartilage damage in patellofemoral joint.

The presence of patellar cartilage defect and its size changes with increased age and BMI (4,5,9,21, 22). However, there is limited information about the age and cartilage loss (4,5,9). Cartilage defect in the patella is an early sign of cartilage loss (2,4,8,12,19). Hanna *et al* found a positive association between age and cartilage defect in a study which included asymptomatic women (9). Age-related widening of the bone surface and decreased cartilage volume fa-

ilitates the defect formation (4,5,9). Autopsy studies showed that patellar cartilage is progressively thinned in women aged 50 and over (16). Studies showed that the association of age and cartilage defect is more prominent in the patella and in women (4,5). Ding *et al* reported the prevalence of patellar cartilage damage as 31% under age 45 and 54% above age 45 (5). Overall, these findings support that articular cartilage defect is seen more with increased age. Similar to previous findings, we found that the prevalence of patellar cartilage defect increased with age in both sexes.

The increase in the BMI parallel to the increase in adipose tissue in whole body was found to be a reason for articular cartilage defect in previous studies (4,5,8,9,20-22). Increased body weight causes a biomechanical effect on patellar cartilage as it increases the load (2,8,11,13,19,20). It seems that the biomechanical effect is not the only factor since osteoarthritis may also occur in other joint cartilage such as in the hand, which does not carry any load. Adipose tissue is considered to be an endocrine organ that releases adipokine and cytokine, which plays a role in cartilage destruction (2,3,6,8,11,13,19,20). Teichtahl *et al* found that adipose tissue related obesity is a risk factor both in males and females for cartilage defect (19). However, the mechanism between adipose tissue level and cartilage defect is still not clear (14). Our results are in line with previous studies. We found a positive association between BMI and patellar cartilage defect in both sexes.

IPFP is an important source of inflammatory mediators in the knee (1,3). Moreover, adipokine and cytokine, which are released from infrapatellar adi-

pose tissue, have more catabolic effects than subcutaneous adipose tissue on articular cartilage (6,11). Overall body adiposity can be regulated, whereas IPFP cannot be modified. The knee also has intra-articular adipose tissue and therefore increased risk factors for osteoarthritis (3). There are only a few findings related to the development and progression of osteoarthritis. Chuckpaiwong *et al* carried out the first study in which an association between osteoarthritis and fat pad volume in women was determined. They found that an age-related increase in IPFP volume increases the vulnerability to osteoarthritis (3). However, the association between IPFP and cartilage defect is still unknown.

In the current study, IPFP volume was lower in patients with cartilage defect when compared to the controls. This was statistically significant in women only. Similar to the findings of Chuckpaiwong *et al*'s study, we did not find any relationship between BMI and IPFP. In contrast to that study, ours included men. It is known that adipose tissue is more common in women than in men (19,20). As adipose tissue has detrimental effects on cartilage, it is not expected to find lower IPFP volume in women. However, as our study is a cross-sectional study, it is not possible to interpret causality. This can be answered in prospective longitudinal studies.

To the best of our knowledge, this is the first study evaluating the relationship between patellar cartilage defect and IPFP volume. Our study, however, has some limitations. First, it was not possible to evaluate the clinical findings of patients who had undergone an MRI and had cartilage defects.

In conclusion, increased age and BMI are important risk factors for patellar cartilage defect in men and women. It was not possible to say whether the decrease in IPFP volume was a cause or the result of the damage in patellar cartilage. Prospective studies analyzing the intra-articular fat pad volume in different age groups and the grade of patellar defect will help to identify the causative relationship between fat pad volume and patellofemoral joint chondral damage.

Acknowledgments

We thank Dr. Anita L. Akkas (PhD in English Literature) for contributing to the English editing.

REFERENCES

1. **Berenbaum F, Eymard F, Houard X.** Osteoarthritis, inflammation and obesity. *Curr Opin Rheumatol* 2013 ; 25 : 114-118.
2. **Berry PA, Wluka AE, Davies-Tuck ML, Wang Y *et al.*** The relationship between body composition and structural changes at the knee. *Rheumatology (Oxford)*. 2010 ; 49 : 2362-2369.
3. **Chuckpaiwong B, Charles HC, Kraus VB, Guilak F *et al.*** Age-associated increases in the size of the infrapatellar fat pad in knee osteoarthritis as measured by 3T MRI. *J Orthop Res* 2010 ; 28 : 1149-1154.
4. **Ding C, Cicuttini F, Scott F, Boon C *et al.*** Association of prevalent and incident knee cartilage defects with loss of tibial and patellar cartilage : a longitudinal study. *Arthritis Rheum* 2005 ; 52 : 3918-3927.
5. **Ding C, Cicuttini F, Scott F, Cooley H *et al.*** Association between age and knee structural change : a cross sectional MRI based study. *Ann Rheum Dis* 2005 ; 64 : 549-555.
6. **Distel E, Cadoudal T, Durant S, Pognard A, *et al.*** The infrapatellar fat pad in knee osteoarthritis : an important source of interleukin-6 and its soluble receptor. *Arthritis Rheum* 2009 ; 60 : 3374-3377.
7. **Gagliardi JA, Chung EM, Chandnani VP, Kesling KL *et al.*** Detection and staging of chondromalacia patellae : relative efficacies of conventional MR imaging, MR arthrography, and CT arthrography. *AJR Am J Roentgenol* 1994 ; 163 : 629-636.
8. **Gunardi AJ, Brennan SL, Wang Y, Cicuttini FM *et al.*** Associations between measures of adiposity over 10 years and patella cartilage in population-based asymptomatic women. *Int J Obes (Lond)* 2013 ; 37 : 1586-1589.
9. **Hanna FS, Bell RJ, Davis SR, Wluka AE *et al.*** Factors affecting patella cartilage and bone in middle-aged women. *Arthritis Rheum* 2007 ; 57 : 272-278.
10. **Jiang L, Tian W, Wang Y, Rong J *et al.*** Body mass index and susceptibility to knee osteoarthritis : a systematic review and meta-analysis. *Joint Bone Spine* 2012 ; 79 : 291-297.
11. **Klein-Wieringa IR, Kloppenburg M, Bastiaansen-Jenniskens YM, Yusuf E *et al.*** The infrapatellar fat pad of patients with osteoarthritis has an inflammatory phenotype. *Ann Rheum Dis* 2011 ; 70 : 851-857.
12. **Kok HK, Donnellan J, Ryan D, Torreggiani WC.** Correlation between subcutaneous knee fat thickness and chondromalacia patellae on magnetic resonance imaging of the knee. *Can Assoc Radiol J* 2013 ; 64 : 182-186.
13. **Lee S, Kim TN, Kim SH.** Sarcopenic obesity is more closely associated with knee osteoarthritis than is nonsarcopenic obesity : a cross-sectional study. *Arthritis Rheum* 2012 ; 64 : 3947-3954.
14. **Mattila VM, Weckstrom M, Leppanen V, Kiuru M *et al.*** Sensitivity of MRI for articular cartilage lesions of the patellae. *Scand J Surg* 2012 ; 101 : 56-61.

15. **McCauley TR, Kier R, Lynch KJ, Jokl P.** Chondromalacia patellae : diagnosis with MR imaging. *AJR Am J Roentgenol* 1992 ; 158 : 101-105.
16. **Meachim G, Bentley G, Baker R.** Effect of age on thickness of adult patellar articular cartilage. *Ann Rheum Dis* 1977 ; 36 : 563-568.
17. **Pihlajamaki HK, Kuikka PI, Leppanen VV, Kiuru MJ et al.** Reliability of clinical findings and magnetic resonance imaging for the diagnosis of chondromalacia patellae. *J Bone Joint Surg Am* 2010 ; 92 : 927-934.
18. **Rose PM, Demlow TA, Szumowski J, Quinn SF.** Chondromalacia patellae : fat-suppressed MR imaging. *Radiology* 1994 ; 193 : 437-440.
19. **Teichtahl AJ, Wang Y, Wluka AE, Szramka M et al.** The longitudinal relationship between body composition and patella cartilage in healthy adults. *Obesity (Silver Spring)* 2008 ; 16 : 421-427.
20. **Teichtahl AJ, Wluka AE, Wang Y, Hanna F et al.** Obesity and adiposity are associated with the rate of patella cartilage volume loss over 2 years in adults without knee osteoarthritis. *Ann Rheum Dis* 2009 ; 68 : 909-913.
21. **Wang Y, Ding C, Wluka AE, Davis S et al.** Factors affecting progression of knee cartilage defects in normal subjects over 2 years. *Rheumatology (Oxford)* 2006 ; 45 : 79-84.
22. **Wluka AE, Ding C, Jones G, Cicuttini FM.** The clinical correlates of articular cartilage defects in symptomatic knee osteoarthritis : a prospective study. *Rheumatology (Oxford)* 2005 ; 44 : 1311-1316.