Original Article

Association Between Body Mass Index and Meniscal Tears Requiring Surgery

Volkan Kızılgöz[1], Gökhan Ragıp Ulusoy[2], Hasan Aydın[3], Kadri Yıldız[2], Türkhun Çetin[1], Mültehan Evran[4]

From,[1]Assistant Professor, Department of Radiology, [2]Assistant Professor, Department of Orthopaedics, [4]Resident, Department of Public Health, Kafkas University, Kars-Turkey, [3]Associate Professor, Department of Radiology, Abdurrahman Yurtaslan Ankara Oncology Research and Training Hospital, Ankara-Turkey.

Correspondence to: Dr.Volkan Kızılgöz, Assistant Professor, Kafkas University, Faculty of Medicine, Department of Radiology, Kars-Turkey. Email: volkankizilgoz@gmail.com

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ABSTRACT

Aim: This study evaluated the association between body mass index (BMI) and operated patients due to meniscal injuries of the knee. We also investigated the influence of BMI on meniscal tears with regard to age. **Methods**: We investigated 104 patients who had surgery for meniscal injuries and 111 patients who had knee magnetic resonance imaging (MRI) with no prior history of meniscal surgery. The relationship between BMI and meniscal injuries which required meniscal surgery was evaluated by independent samples T-test. A cutoff BMI value has been tried to find out by receiver operating characteristics (ROC). The odds ratio has been calculated with regard to this cutoff value. Patients were classified into three age groups ≤30, 31–50 and ≥51 years old. Chi-square was used to determine whether age affected the BMI relationship with meniscal injuries which required surgery. **Results**: BMI values were significantly higher in surgical patients compared to controls (p = 0.005). To compare surgical and non-surgical patients, ROC analysis was used and area under curve (AUC) value was calculated as 0.605. A BMI value of 27.90 had the highest specificity (92.0%) and sensitivity (40.4%), and the odds ratio calculated by Pearson chi-square was 3,08 for this BMI value. The most significant difference in BMI between surgical and non-surgical patients was observed in the 31–50 age group (p = 0.007). There was no significant difference in BMI between surgical and non-surgical patients in the <30 age group (p=0,404). **Conclusion**: Higher BMI increases the risk of meniscal tears requiring surgery, especially in the 31–50 age groups. Patients might benefit from weight regulation since BMI is thought to be an important modifiable risk factor for meniscal tears.

Key words: *Meniscus, meniscal tear, meniscectomy, body mass index, body weight*

The menisci are two crescent-shaped fibrocartilaginous structures located between the femur and tibia on both the medial and lateral sides of the joint. The menisci distribute the axial force, reducing shock and friction during knee joint movement [1,2]. Meniscal injuries are commonly associated with athletic activities [3,4]. Height and weight affects the incidence of knee joint injuries among athletes [5] In younger populations, a meniscal tear is usually caused by trauma, but a traumatic meniscal tears are typically seen in adults over the age of 40 [6]. They might be a result of various factors such as age, sex, activity level, obesity, or abnormal leg axis [7-10].

Degenerative meniscal changes are thought to be predisposing factors of meniscal tears [11]. High body weights increase subchondral bony stiffness and thus, transmit more force to the overlying cartilage [12-13].

Thus, obesity could be a possible factor in menisci injury [14]. In terms of age distribution, the relationship of BMI to increased meniscal tear risk which requires surgery is strongest in the 31–50-years-old group. A BMI value of 27.9 had relatively low sensitivity, but high specificity, to compare these patients (operated) and control (non-operated) groups. The menisci are thought of as shock absorbers which provide stability throughout load transfer across the knee joint. In addition, they relieve stress transmitted through the articular cartilage and subchondral bone [16-19]. In the knee joint, the menisci are believed to transmit over half of the load [20]. The mechanisms of meniscal injury are not limited to BMI and weight-related biomechanics. Low grade inflammation associated with obesity [21] or reduced blood flow to the menisci [22-25] could also lead to meniscal injuries. Also, the mechanical effect of BMI through stress transmission during rotational movements of the knee may not be the only explanation for meniscal injuries. The blood supply of the meniscal tissue could be limited due to higher vascular compression or increased cardiovascular risk factors in obese individuals [14]. Meniscal blood supply is also thought to influence healing of meniscal tears [18,23,26].

In this study, we investigated the relationship between body mass index (BMI) and operated meniscal tears. In addition, the influence of BMI on meniscal tears which required surgery was evaluated with regard to age and sex.

METHODS

This case-control study was approved by our institutional ethical committee. We re-assessed 119 consecutive patients who underwent arthroscopic surgery between January 2015 and December 2017. Patients who had no axial knee deformity, no previous surgery, and no history of inflammatory arthritis, were included in this study. We excluded patients <18 years old since this study targeted the adult population. After exclusions, 104 patients were enrolled in the study as the patient group. For the control group, we studied 111 consecutive patients who were admitted to the orthopedics department between May 2018 and July 2018 with knee pain and had normal magnetic resonance imaging (MRI) results.

The BMI of patients were calculated by height and weight values which were obtained from the patient files for the patient group. For the control group, each patient's height and weight were measured manually for the study. The arthroscopic results of the patient group were acquired from patient records, and the MRI results of the control group were obtained from the images in the picture archiving and communications system (PACS). The patients were classified into age groups of ≤30, 31–50 and ≥51 years old and the effect of BMI on each of these groups were calculated with regard to the operated and non-operated patient groups.

Knee MRIs were obtained with a 1.5-T MRI device (Magnetom Essenza Siemens, Erlangen, Germany) with an 8-channel knee coil. The routine knee MRI protocol was as follows: sagittal T1 weighted images [repetition time (TR), 515 ms; echo time (TE), 14 ms; matrix, 192 ×256; field of view (FOV), 160 mm; slice thickness, 3.5 mm; interslice gap, 0.7 mm; echo train length, 55; number of excitations (NEX), 2], axial proton density weighted (PDW) images (TR, 2500 ms; TE, 28 ms; matrix, 206 ×256; FOV, 170 mm; slice thickness, 3.5 mm; interslice gap, 0.7 mm; echo train length, 69; NEX, 1), coronal PDW images (TR, 2350 ms; TE, 26 ms; matrix, 205 × 256; FOV, 180 mm; slice thickness, 3.5 mm; interslice gap, 0.7 mm; echo train length, 69; NEX, 1), and sagittal PDW images (TR, 2670 ms; TE, 24 ms; matrix, 205× 256; FOV, 190 mm; slice thickness, 3.5 mm; interslice gap, 0.7 mm; echo train length, 70; NEX, 1). The mean time interval between the injury and the MRI was 2,3 days (Range: 1–29 days).

The MRI grading system, reported by Lotysch et al.[15]. was used to classify the abnormally high meniscal signal intensity. A small focal area of hyperintensity without extension to the articular surface, was classified as grade 1; linear areas of hyperintensity without extension to the articular surface, was classified as grade 2; linear abnormal intensity without extension to the articular surface of the meniscus, was classified as grade 2a; abnormal hyperintensity that reaches the articular surface on a single image was classified as grade 2b; and globular wedge-shaped abnormal hyperintensity without extension to the articular surface of the meniscus was classified as grade 2c. Abnormal hyperintensity, which extends to at least one of the articular surfaces of the meniscus (superior or inferior articular surface), was classified as grade 3, and hyperintensities in grade 3 were considered a definite meniscal tear.

All statistical analyses were performed with commercially available software (MedCalc Software bvba & Acacialaan 22 8400 Ostend Belgium). The results of a prior power analysis showed that ≥ 107 individuals in each group would be needed to determine a statistically significant effect of BMI between meniscus-surgery and non-surgery groups, with an accepted type 1 error of 0.05 and power of 80%. The difference in BMI values between the surgery and non-surgery patients were calculated by an independent samples T-test. This calculation method was also used to analyze the difference between surgical and non-surgical patients in terms of height and weight values. Receiver operating characteristics (ROC) analysis was applied to measure the BMI cutoff point. The effect of age and BMI on surgery incidence was determined by chi-

square test with regard to this cutoff value. The p values less than 0.05 were accepted as "statistically significant" in all of these analyses.

RESULTS

We studied 104 individuals who had surgery for meniscal tears and 111 patients who had normal menisci confirmed by MRI. All of the surgically repaired meniscal tears were classified as grade 3, and there was no mismatch between abnormal hyperintensity in MRI and surgical results in the operated group.

The mean (mean ± standard deviation) age of the surgical patients was 41.5 ± 12.9 years and non-surgical patients were 41.1 ± 13.5. There were 125 males (58 in the surgery group and 67 in control) and 90 females (46 in surgery group and 44 control) included in the study . There was no significant difference between the surgery and control patients with regard to age (p=0.838) (Table 1).
The average weight of the surgical patients was significantly higher than the control group (p=0.014), but height was not different (p=0.482).

Table 1 Distribution of the patients: age & anthropometric

Distribution of the patients	Group	N	Mean	Std. Deviation	*p* value
Age	Operated	104	41.45	12.93	0.838
	Non-Operated	111	41.08	13.53	
Height	Operated	104	1.70	0.08	0.482
	Non-Operated	111	1.71	0.07	
Weight	Operated	104	78.78	13.25	0.014
	Non-Operated	111	74.84	10.05	

Table 2: Comparison of operated and non-operated patients with regard to the cutoff value of BMI

Number of patients with regard to BMI values (n)	Group		Total
	Operated	Non-operated	
BMI values of ≤ 27.90	62	91	153
BMI values > 27.90	42	20	62
Total	104	111	215
Pearson chi-square test *p*<0.001 Odds ratio: 3.08			

Mean BMI of operated patients was significantly higher (27.0 ± 4.7) than the control group (25,.4 ± 3.5, p=0.005). Using the ROC analysis, we determined that a cutoff BMI value of 27.9 would be the most suitable to categorize surgery groups (Figure 1). The odds ratio for this cutoff was 3.08 to compare with Pearson chi-square test (Table 2).

There was no significant difference between the <30 years old groups in regard to BMI, but BMI was different between surgery groups in the 31–50 age group (p=0.007, Table 3).

Table 3 Patients' data for different age groups and BMI values

Age Group	BMI Value in patients	Groups		Total	P Value
		Operated	Non Operated		
<30 Years	≤ 27.90	21	26	47	0.404
	> 27.90	4	2	6	
Total		25	28	53	
30-51 Years	≤ 27.90	28	45	73	0.007
	> 27.90	22	11	33	
Total		50	56	106	
>51 Years	≤ 27.90	13	20	33	0.026
	> 27.90	16	7	23	
Total		29	27	56	

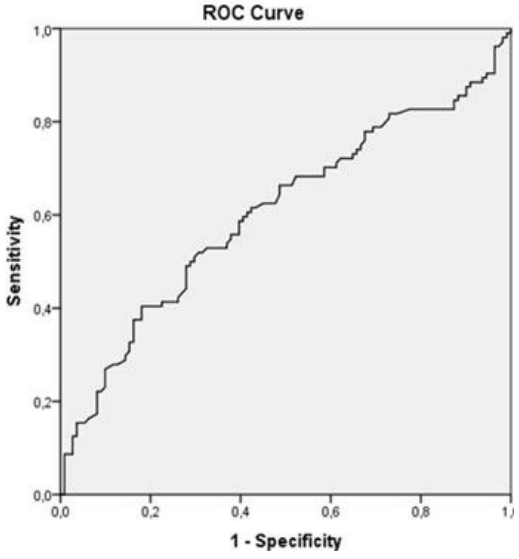

Figure 1: BMI values according to the receiver operating characteristics (ROC) with area under curve (AUC) value of 0.605.

DISCUSSION

This study demonstrated a significant association between

BMI values and meniscal injuries which required surgery. We observed that BMI was significantly higher in patients who had surgery for meniscal tears, suggesting weight as a risk factor. There is a widespread suspicion that age may affect meniscal tear healing, but this relationship is not well demonstrated in the literature [16,27-31]. Previous reports show a relationship between age and healing [27-29], while others show no apparent association [30,31]. To the best of our knowledge, there was no information about the relationship between BMI and meniscal tears before the study of Ford et al. in 2005. According to this study, higher BMI values were significantly related to the need for meniscal surgery. There were elevated age-adjusted odds ratios in males with a BMI of ≥ 27.5 and in females with a BMI of ≥ 25.0 [14]. In the current study, a BMI value of 27.9 was found to better represent the best cutoff point in terms of better sensitivity and specificity. However, this comparison should not represent a perfect match, as only 50-79 year-old individuals were included in the study of Ford et al., while the current study included patients of ≥18 years old.

In the current study, 31-50 age groups has relatively high incidence of surgeries and this might be a result of the pre-existing osteoarthritis. It is known that the mechanical properties of the cartilage are sensitive to composition and structure [32]. In the early phase, the loss of glycosaminoglycan content leads to alteration in the resistance of cartilage to compressive forces and alteration of osmotic pressure within the cartilage tissue [33]. Later in this early phase, catabolic activity occurs and increased expression of stress response factors, cartilage-degrading proteinases and inflammatory mediators leads to cartilage loss[32]. Collagen type II fragments of the damaged cartilage surface may induce inflammatory responses in the synovial membrane which leads to lymphocytic infiltration, hyperplasia and perivascular aggregates[34] The inflamed synovium causes inflammatory mediators which may promote cartilage degradation [35] The study of Englund et al. demonstrated that a meniscal tear in middle- aged and elderly persons without any previous knee surgery, but who otherwise carry the risk of osteoarthritis, is common and precedes and this group is strongly associated with the development of radiographic tibiofemoral osteoarthritis [36] It has been known that meniscal tears can lead to osteoarthritis. On the other hand, osteoarthritis may lead to spontaneous meniscal tears through breakdown, weakening of the structure of menisci. Degenerative meniscal lesions in the middle-aged or older patients could suggest early osteoarthritis of the knee [37].

There are several limitations that warrant discussion. First, we included young adults and elderly patients in our study. Athletic injuries (due to sport activities etc.) may influence the results of the younger cohort more so than the elderly population. Second, there was not enough information available to determine confounding factors such as tobacco use, diabetes, or hypertension, which might affect the vessels and blood supply to the meniscal tissue. This lack of information might be an important aspect to consider in the greater context of the current findings. Third, anatomical variances of the lower limb (which are related to the femur and tibia) and angulation of femur and tibia might influence the injury locations, i.e., as tears of the medial or lateral meniscus. For example, the quadriceps angle was not measured in each patient, which might influence the results by altering the axial force on the weight bearing side. Fourth, the minimum number of patients determined by our power analysis was ≥107 for both the surgical and non-surgical patient group. Our cohort fell slightly short of this statistical recruitment goal, so we might be underpowered. Fifth, BMI was accepted as a modifiable risk factor but "body fat" would be better to be accepted as a modifiable risk factor since muscular persons would also have higher BMI. Body fat should be taken into account as the real modifiable risk factor, however, this study has not been designed on body fat and related measurements like fat percentages indicating the weight composition with regard to fat and muscle distributions consisting the total weight of the body. Sixth, occupation can also be accepted as a risk factor of meniscal tears which was not taken into account in this study. Daily activities, sport activities and lifestyle, which may cause repetitive traumas to menisci, may increase the risk of injuries.

CONCLUSION

In conclusion, higher BMI values appear to increase the risk of meniscal tears requiring surgery. This relationship was strongest in the 31–50 age groups. Thus, BMI seems to be a modifiable risk factor for meniscal injuries which requires surgery; therefore, patients might benefit from weight management to prevent surgery due to meniscal injuries.

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