Is There A Relationship Between Three-Dimensionally Measured Baker's Cyst Volume and Knee Pathologies?

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ABSTRACT

Objective: Baker's cyst (BC) is also known as popliteal cyst. To evaluate its effect on intra-articular pathology, it is important to have the exact volume of the cyst. As BC may change its shape due to mass effect of the surrounding anatomic structures, it is difficult to measure the exact volume of BC. This study examined the relationship between three-dimensionally measured BC volume and symptomatic intra-articular knee pathologies.

Materials and Methods: The magnetic resonance (MR) images of 45 patients with symptomatic knees were retrospectively examined.

The BC volumes were measured via volumetric analysis. The joint effusion was examined in the sagittal plane in T2-proton density-weighted images. The medial plicae were assessed in accordance with the modified Sakakibara classification. Using the MR images, the meniscuses were classified in accordance with the meniscus rupture classification of Stoller et al. The cartilaginous lesions were analyzed using an MR grading system.

In this study, correlations between the following measures were analyzed: BC volume and effusion level, medial plica presence, medial femoral condyle, medial tibial condyle, lateral femoral condyle and lateral tibial condyle cartilage degeneration, and medial meniscus anterior horn, medial meniscus posterior horn, lateral meniscus anterior and posterior horn ruptures.

Results: Cartilage degeneration, medial plicae, increase in intra-articular effusion, and increase in the BC volume were found to be statistically significant ($p<0.01$).

Conclusion: Cartilage degeneration, medial plicae, and increase in intra-articular effusion may increase the BC volume. We believe that this study may contribute to clinicians in understanding the relationship between BC volume changes and pathologies causing intra-articular knee symptoms.

Keywords: Popliteal cyst, MRI, knee pain, knee joint

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Introduction

In a symptomatic knee joint, effusion, medial plicae, and meniscal and cartilaginous pathologies are frequently observed [1-5]. The intra-articular knee pathologies accompanying Baker's cysts (BCs) generally develop at the popliteal fossal level. BCs were first identified in 1840 by Adams; however, in 1877, Baker reported that BCs exhibit a one-way relationship with joint spacing [6, 7]. These cysts are formed because of fluid accumulation within the gastrocnemius tendon bursa caused by an increase in intra-articular effusion. They are also known as popliteal cysts [6]. Direct excision, aspiration, and arthroscopic methods are widely used to treat BCs [7-10]. Despite the diversity of treatment options, a high recurrence level has been observed even after its treatment [11, 12].

Although the association between intra-articular pathologies and BCs is known, high recurrence levels have been reported when these pathologies were neglected during treatment [13, 14]. This situation increases the importance of determining the relationships with the real dimensions of these cysts, as well as the associations between intra-articular pathologies and BCs.

BC is under pressure, together with increases in the gastrocnemius and semimembranosus muscle tonus, while standing or when the knee is in full extension. BC becomes clinically evident in this position. When the knee is in flexion, these muscles relax, and softening occurs, along with a decrease in the stress within the cyst. This may negatively affect the clinically ob-

jective determination of the size of the BC, because the cyst changes it shape along with the mass action of the anatomical structures surrounding the cyst [15]. In addition, when these cysts are examined in three dimensions, they do not always exhibit spherical shapes. Hence, measuring the cyst diameter may not yield objective results when determining the cyst volume. Thus, the volume measurement is very important to determine the real size of a BC, which can be measured as a three-dimensional (3D) volume using multiplanar magnetic resonance (MR) images. Although this measurement can accurately yield the absolute volume, there are no studies in the literature examining the relationships between 3D BC volumes and intra-articular joint pathologies. Therefore, this study was designed to examine the 3D BC volume relationships with symptomatic intra-articular joint pathologies.

Materials and Methods

This study was carried out by retrospectively examining the hospital records and MR images of 2067 patients who underwent knee MR imaging in the Recep Tayyip Erdoğan University,Faculty of Medicine at the Training and Research Hospital of University between August 2016 and May 2017. Forty-five patients aged between 40 and 55 years with symptomatic knees and no histories of knee or surrounding area surgeries who had BCs in their MR images were involved in this study. The exclusionary criteria were as follows: younger than 40 years, older than 55 years, traumatic and inflammatory knee symptoms, masses at or around the knee, and surgical histories.

This study was carried out in accordance with the principles outlined in the Declaration of Helsinki. For searching archived material permission was obtained from the hospital administration. The MR images of the patients involved in this study were re-examined by a radiologist.

MR assessment

The knee MR images were examined in terms of the BC volume, joint effusion level, medial plica presence, cartilage degeneration in the medial femoral condyle (MFC), medial tibial condyle (MTC), lateral femoral condyle (LFC), and lateral tibial condyle (LTC), and rupture presence in the medial meniscus anterior horn (MMAH), medial meniscus posterior horn (MMPH), lateral meniscus anterior horn (LMAH), and lateral meniscus posterior horn (LMPB).

BC volume measurement

The BCs were evaluated via volumetric analysis (syngo.via® VA20 software; Siemens Healthcare, Forchheim, Germany) using multiplanar reformatting and volumetric rendering techniques. The BC volume was measured as follows: slices from every 3 mm were extracted, and the cross-sectional area of the BC was measured from top to bottom by manually tracing the internal surface of the cyst. The software automatically calculated the volume of the cyst by adding the products of the 3 mm and cross-sectional areas (Figure 1).

The joint effusion was examined in the sagittal plane in T2-proton density-weighted short-tau inversion recovery (STIR) images. The measurements were performed transversely in an intercondylar cross-section from 1 cm proximal to the top of the patella. The results were divided into two groups: below 1 mm and above 1 mm.

The medial plicae were assessed in accordance with the modified Sakakibara classification [16]. The assessment results were divided into two groups: no plica and other.

Using the MR images, the meniscuses were classified as normal, Grade I, Grade II, or Grade III in accordance with the meniscus rupture classification of Stoller et al. [17]. The normal meniscuses were homogenous at low signal intensities in the T1- and T2-weighed spin echo, fast spin echo, gradient echo, and STIR sequences. In the Grade I meniscuses, nonarticular focally or globally increased intrasubstance signal intensities were observed. In Grade II, there was a linear intrasubstance signal increase horizontally extending from the periphery of the meniscus. In Grade III, the area of increased signal intensity incorporated a minimum of one surface of the joint.

The cartilaginous lesions were analyzed using an MR grading system. Grade 0 indicated normal cartilage. Grade I indicated focal cartilaginous swelling and low signal intensity fields within the cartilage. Grade II indicated surface irregularities and a <50% loss of height in the cartilage. Grade III indicated deep ulceration and a >50% loss of height in the cartilage. Grade IV indicated the appearance of subchondral bone [18].

Results

The mean age of the patients was 46 years (range: 40-55 years); 20% of the patients were females, and 80% were males. The mean BC volume was 13.55±7.11 cm^3, and plicae were found in 22.2% of the patients. There was a statistically significant difference between an increase in the BC volume and the presence of plicae in the knee joint. The effusion size was less

Table 1. Relationships between the cartilage pathologies and the Baker's cyst volume

	Grade (G)	%	Mean	±SD	p
MFC	G1	37.7	12.7871	9.02387	
	G2	40	11.3972	3.97737	
	G3	22.2	18.7340	5.71341	p=0.024
MTC	G1	77.7	11.5174	6.56043	
	G2	13.3	18.8067	3.30986	
	G3	8.8	23.4800	1.25637	p=0.000
LTC	G1	62.2	10.9546	6.18887	
	G2	22.2	16.0680	5.91703	
	G3	15.5	20.3514	7.10134	p=0.002
LFC	G1	84.4	13.2247	6.97254	
	G2	4.4	19.4650	6.96500	
	G3	11.1	13.6800	8.75016	p=0.492

MFC: Medial femoral condyle; MTC: Medial tibial condyle; LTC: Lateral tibial condyle; LFC: Lateral tibial condyle

Table 2. Relationships between the meniscus pathologies and the Baker's cyst volume

	Grade (G)	%	Mean	±SD	p
MMAH	GI	48.8	12.9805	6.28513	
	G2	40	12.8139	7.98198	
	G3	11.1	18.7300	6.40197	p=0.229
MMPH	GI	17.7	16.8313	8.51114	
	G2	31.1	14.2893	5.48554	
	G3	51.1	11.9639	7.31670	p=0.228
LMAH	GI	60	11.4433	6.63048	
	G2	26.6	16.6250	7.48083	
	G3	13.3	16.9000	5.80331	p=0.048
LMPH	GI	55.5	12.8712	7.37056	
	G2	35.5	14.9263	7.12328	
	G3	8.8	12.3175	6.18700	p=0.634

MMAH: Medial meniscus anterior horn; MMPH: Medial meniscus posterior horn; LMAH: Lateral meniscus anterior horn; LMPH: Lateral meniscus posterior horn

Table 3. Relationships between the gender, plicae, and effusion and the Baker's cyst

		%	Mean	±SD	p
Gender	Female	80	12.5317	6.69781	
	Male	20	17.6367	7.66401	p=0.053
Effusion	<1 mm	66.6	11.0870	6.13393	
	≥1 mm	33.3	18.4840	6.48830	p=0.001
Plicae	No	77.7	12.1474	6.55471	
	Yes	22.2	18.4710	7.11695	p=0.011

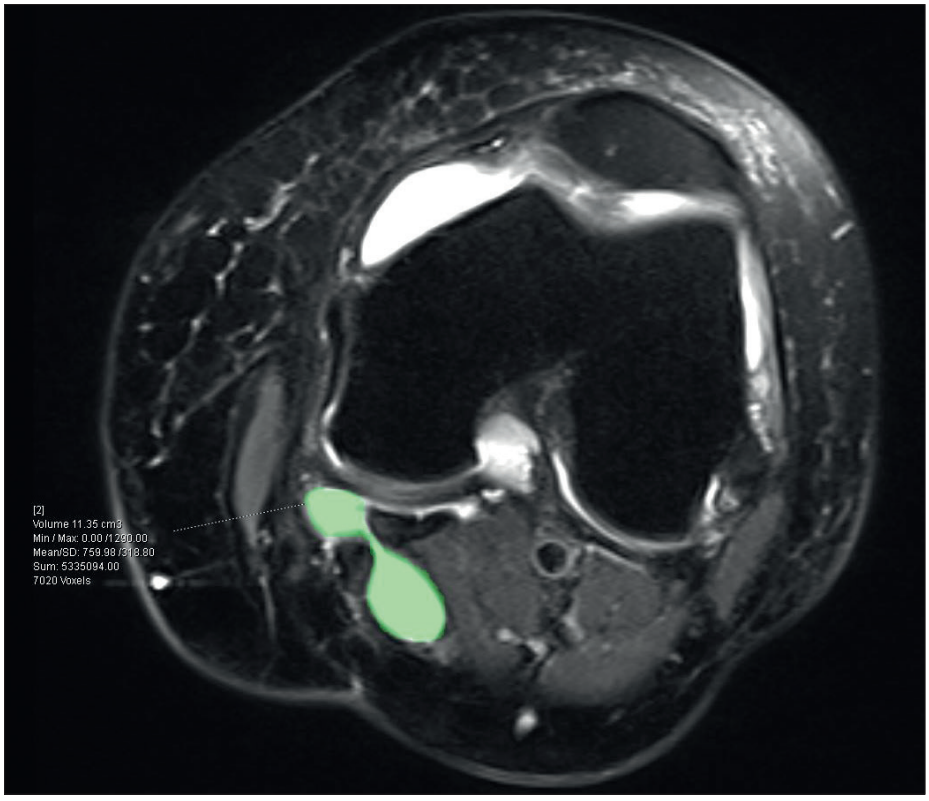

Figure 1. The software automatically calculated the cyst volume by adding the products of the 3 mm and cross-sectional areas

than 1 mm in 66.7% of the patients and greater than 1 mm in 33.3%. There was an increasing correlation between the BC volume and effusion amount, which was statistically significant.

The MMAH damage degrees were 48.9% for GI, 40% for GII, and 11.1% for GIII. The MMPH damage degrees were 17.8% for GI, 31.1% for GII, and 51.1% for GIII. The LMAH damage degrees were 69% for GI, 35.6% for GII, and 8.9% for GIII. However, there were no statistically significant differences between the increases in the BC volume and the degrees of medial and lateral meniscus damage.

The MFC damage degrees were 37.8% for GI, 40% for GII, and 22.2% for GIII. The MTC damage degrees were 77.8% for GI, 13.3% for GII, and 8.9% for GIII. The LTC damage degrees were 62.2% for GI, 22.2% for GII, and 15.6% for GIII. There were statistically significant differences between the increases in the BC volume and the cartilage degeneration levels in the MTC, MFC, and LTC.

The LFC damage levels were 84.4% for GI, 4.4% for GII, and 11.1% for GIII. However, there was no statistically significant difference regarding

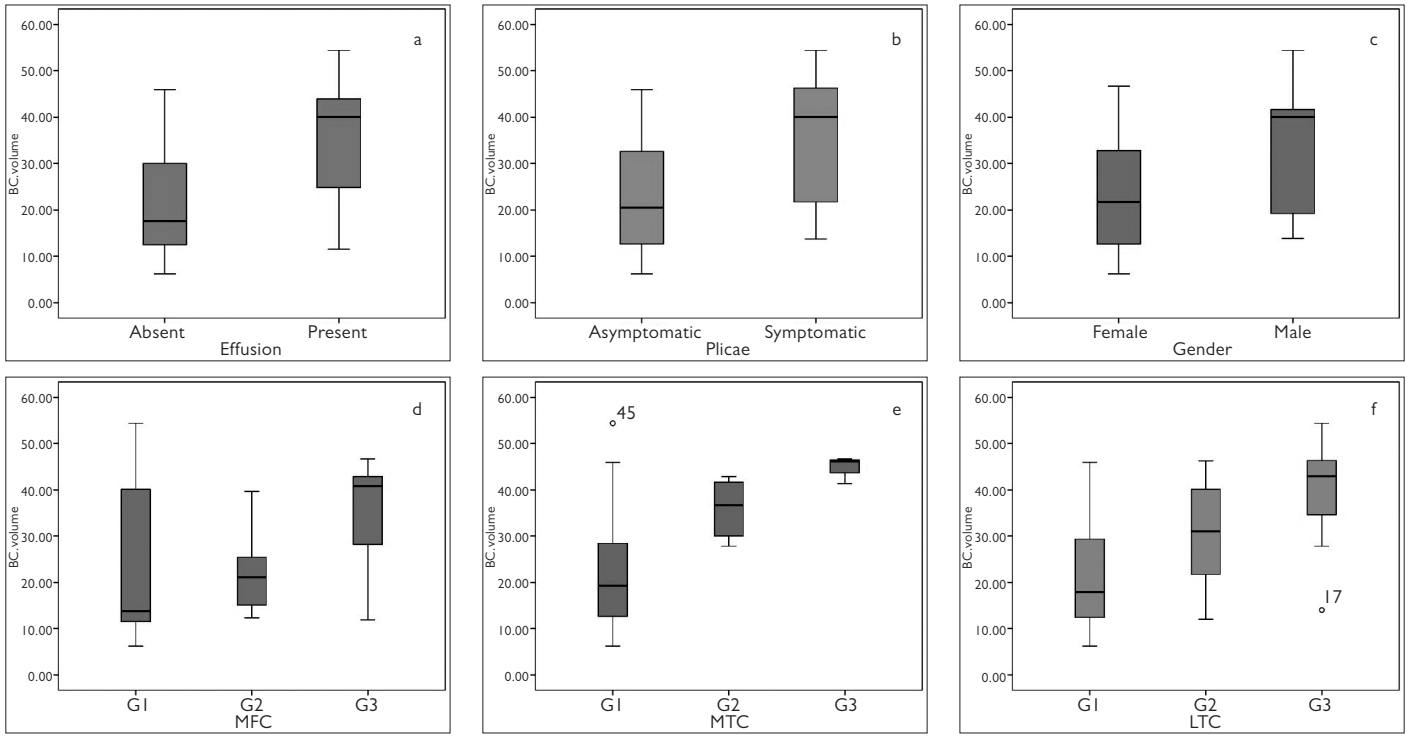

Figure 2 a-f. (a) Baker's cyst volumes in the effusion, (b) Baker's cyst volumes in plicae, (c) Baker's cyst volumes in gender, (d) Baker's cyst volumes in the medial femoral condyle, (e) Baker's cyst volumes in the medial tibial condyle, (f) Baker's cyst volumes in the lateral tibial condyle

the cartilage degeneration level in the LFC.

Mean BC volumes of the symptomatic knee pathologies are presented in Tables I–III.

The mean values describing the intra-articular knee pathologies and BC volumes, as well as the statistical examination results, are presented in Table 1. The error bars indicating the 95% confidence intervals of the BC volume levels are presented in Figure 2.

Statistical Analysis

The Statistical Package for the Social Sciences version 17.0 (SPSS Inc., Chicago, IL, USA) was used for all of the analyses. It was observed using the Kolmogorov–Smirnov test that the dependent variables exhibited non-normal distribution. For this reason, the Kruskal–Wallis test was used to compare the mean values of more than two groups, whereas the Mann–Whitney U test was used for the comparisons made between two groups. After the Kruskal–Wallis test, the Bonferroni correction was used to determine the group creating the difference. Since three comparisons were made, the p value was set at 0.17 by dividing 0.05 by 3.

Discussion

Popliteal cysts can be observed in symptomatic knees at frequencies varying between 38% and 55%, which has increased the interest in BC research [5, 11, 19]. In this study, significant relationships were determined between the intra-articular knee pathologies and the BC volume. The presence of medial plicae, increases in intra-articular effusion, and especially cartilage degeneration are the reasons for the increases in the BC volume.

Calvisi et al. [7] determined that among the cases undergoing arthroscopic treatment methods, the BCs disappeared in 64% and dwindled in 36%. Moreover, they reported clinical recovery in those cases among whom the cyst size decreased. This conclusion indicates that the clinical recovery is related to the cyst size, which shows the importance of determining the real size of a BC in the clinical follow-up and assessing the treatment accordingly.

A 19% prevalence of BCs among symptomatic knees has been reported, and the maximum diameter of these cysts was determined to be greater than 30 mm [20]. This suggests that up to a specific level, the size of the cyst plays no determinant role in the formation of symptoms. Among the knees with BCs, the symptoms generally originate from intra-articular knee pathologies, and the BC-based symptoms are generally related to the size of the cyst [11]. However, a decrease in the cyst size in a symptomatic knee positively influences the clinical outcome of the patient. Moreover, as the size of the cysts increases, it can restrain the joint range of motion by limiting the knee flexion and extension [14]. In this study, the increases in the mean BC volumes in the MTC, MFC, and LTC degeneration cases that were significantly related to the BC volume increases were 42.3%, 27.66%, and 33.2%, respectively. In the cases in which there was a statistically significant relationship among the BC volume, plica presence, and effusion increase, the increases in the volume in proportion to the mean BC volume were 26.64% and 26.68%, respectively. This indicates that the intra-articular symptomatic knee pathologies caused a minimum of 25% increase in the BC volume. Moreover, the maximum increase in the BC volume was observed in the cartilage pathologies incorporating the MTC and LTC.

Sansone et al. [4] reported that 94% of popliteal cysts are related to intra-articular knee pathologies, with meniscus and cartilage-based pathologies constituting the majority. In addition, 70.2% of the meniscus pathologies incorporated medial meniscus ruptures, and most of the ruptures involved the posterior horn. In this study, MMAH and LMAH pathologies were found to have relationships with an increase in the BC volume, but these were not statistically significant. The difference was that the degeneration level was at the early stage in 88.9% of the MMAH and 86.7% of the LMAH pathologies. We believe that this was because not enough change occurred in the intra-articular coherence due to the absence of cartilage degeneration incorporating the joint surface [19]. Furthermore, there

was an early-stage increase in the BC volume in the MMPH and LMPH pathologies. In 91.2% of the LMPH pathologies, the degeneration was at an early stage. In half of the MMPH pathologies, the degeneration was at an advanced stage. Moreover, the meniscus degeneration was at an early stage among the cases with advanced-stage cartilage degeneration. In those cases with early-stage meniscus degeneration, the plicae and effusion levels were high, which indicated that the BC volume increases at the early stages of the LMPH, and MMPH pathologies originated from the plica-caused cartilage degeneration and effusion increase. In the cases observed to have early-stage LMPH and MMPH degeneration, the high degree of MFC degeneration corroborated this conclusion.

Visser et al. [5] reported that a BC distinguishes the structural degeneration, especially on the medial side of the tibiofemoral joint in symptomatic knees. The medial compartment pathologies and the intra-articular coherence changes originating from the deteriorated biomechanics may have positive correlations with the BC by creating an increase in the normal intra-articular knee pressure [19].

In this study, the relationship between a BC and cartilage degeneration also applied to the lateral portion of the tibiofemoral joint, as well as the medial segment. Moreover, there was a statistically significant relationship between medial plicae and BCs. Medial plicae are more frequently observed in knees with osteoarthritis, and they have a positive correlation with the degeneration severity. During routine activities, repetitive friction occurs between the medial plicae and the MFC. The degradation occurring in the condyle due to friction increases the level of change occurring in the medial plicae. Thus, clinical symptoms, such as pain, emerge together with the development of synovitis [3]. Therefore, we believe that the increase in the BC volume in the presence of plicae emerges secondarily to the degenerative process caused by the plicae in the condyle.

An increase in joint effusion may increase the size of the gastrocnemius bursa [2]. During relaxation, the intra-articular pressure in a knee joint with effusion is 33 mmHg, whereas it may reach levels as high as 1300 mmHg during flexion [1]. The synovial fluid may be pumped into the bursa due to the increase in the intra-articular pressure during the flexion of the knee. Corroborating this, this study reports that there was a statistically significant relationship between the BC volume increase and the presence of intra-articular effusion.

Acebes et al. implemented intra-articular steroids and cyst aspiration for patients with knee osteoarthritis and symptomatic popliteal cysts [19]. They reported a reduction in the knee symptoms and a significant decrease in the cyst size during the follow-up period, as well as an increase in the joint range of motion. This emphasizes the effect of the BC size on the function of the knee joint, in addition to the relationship with the intra-articular pathology. In this study, an approximately 70% increase was found in the mean cyst volume of the BCs with statistically significant relationships with the intra-articular pathologies. For this reason, we believe that determining the real size of the BC together with the intra-articular pathology would be useful in predicting symptomatic intra-articular knee pathologies to a larger extent.

Intra-articular knee pathologies have clinical effects depending on the stage of degeneration. From the clinical aspect, the mechanical and inflammatory processes play roles in the formation of these effects. These processes cause cartilage degeneration on the surface of the joint over the course of time, and the BC formation occurs secondarily to the cartilage degeneration [5, 16]. Although their relationships with the BCs were statistically non-significant in this study, meniscus lesions have been reported to increase in the formation of BCs in the literature [4]. Our meniscus pathologies were not advanced enough; they continue with the progression of the degenerative process.

Among adults, generally, BCs exist secondarily to intra-articular deformations, such as degenerative or inflammatory pathologies of the knee [7].

The main limitation of this study was that it was retrospective. Prospective studies with longer follow-up periods on patients arthroscopically diagnosed with intra-articular pathologies and then treated would be able to more objectively reveal the relationship between the BC volume and an intra-articular pathology. However, this study is important because it is a pilot study in this field in terms of the BC measurement techniques.

In this study, statistically significant relationships were determined between the BC volume and cartilage pathologies, medial plicae, and intra-articular effusion. When they become symptomatic, these pathologies may cause increases in the BC volume. In symptomatic knees, the cause-effect relationship between the BC volume and an intra-articular pathology develops secondarily to the degenerative process. We believe that this study may have positive contributions to clinicians in understanding the relationships between BC volume changes and pathologies creating intra-articular knee symptoms, in addition to making conclusions about the clinical importance of these results.

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References

1. Handy JR. Popliteal cysts in adults: a review. Semin Arthritis Rheum 2001; 31: 108-18. [CrossRef]
2. Janzen DL, Peterfy CG, Forbes JR, Tirman PF, Genant HK. Cystic lesions around the knee joint: MR imaging findings. AJR 1994; 163: 155-61. [CrossRef]
3. Lyu SR. Arthroscopic medial release for medial compartment osteoarthritis of the knee: the result of a single surgeon series with a minimum follow-up of four years. J Bone Joint Surg Br 2008; 90: 1186-92. [CrossRef]
4. Sansone V, De Ponti A, Paluello GM, Del Maschio A. Popliteal cysts and associated disorders of the knee: critical review with MR imaging. Int Orthop 1995; 19: 275-9. [CrossRef]
5. Visser AW, Mertens B, Reijnierse M, Bloem JL, de Mutsert R, le Cessie S, et al. Bakers' cyst and tibiofemoral abnormalities are more distinctive MRI features of symptomatic osteoarthritis than patellofemoral abnormalities. RMD Open 2016; 1: e000234. [CrossRef]
6. Billières J, Lascombes P, Peter R. Popliteal cysts: etiologic and therapeutic approach. Rev Med Suisse 2014; 10: 1211-5.
7. Calvisi V, Lupparelli S, Giuliani P. Arthroscopic all-inside suture of symptomatic Baker's cysts: a technical option for surgical treatment in adults. Knee Surg Sports Traumatol Arthrosc 2007; 15: 1452-60. [CrossRef]
8. Rauschning W, Lindgren PG. Popliteal cysts (Baker's cysts) in adults. I. Clinical and roentgenological results of operative excision. Acta Orthop Scand 1979; 50: 583-91 [CrossRef]
9. Di Sante L, Paoloni M, Dimaggio M, et al. Ultrasound-guided aspiration and corticosteroid injection compared to horizontal therapy for treatment of knee osteoarthritis complicated with Baker's cyst: a randomized, controlled trial. Eur J Phys Rehabil Med 2012; 48: 561-7.
10. Malinowski K, Synder M, Sibinski M. Selected cases of arthroscopic treatment of popliteal cyst with associated intra-articular knee disorders

primary report. Ortop Traumatol Rehabil 2011; 13: 573-82. [CrossRef]
11. Marti-Bonmati L, Molla E, Dosda R, Casillas C, Ferrer P. MR imaging of Baker cysts: prevalence and relation to internal derangements of the knee. MAGMA 2000; 10: 205-10. [CrossRef]
12. Vahlensieck M, Linneborn G, Schild HH, Schmidt HM. Magnetic resonance imaging of the bursa around the knee joint. Rofo Fortschr Geb Rontgenstr Neuen Bildgeb Verfahr 2001; 173: 95-9.
13. Sansone V, De Ponti A. Arthroscopic treatment of popliteal cyst and associated intra-articular knee disorders in adults. Arthroscopy 1999; 15: 368-72. [CrossRef]
14. Takahashi M, Nagano A. Arthroscopic treatment of popliteal cyst and visualization of its cavity through the posterior portal of the knee. Arthroscopy 2005; 21: 638. [CrossRef]
15. Foris LA, Bhimji SS. Cyst, Baker. StatPearls. Treasure Island (FL): Stat Pearls Publishing 2017; 17: 6.
16. Hayashi D, Xu L, Guermazi A, et al. Prevalence of MRI-detected mediopatellar plica in subjects with knee pain and the association with MRI-detected patellofemoral cartilage damage and bone marrow lesions: Data from the joints on Glucosamine study. BMC Musculoskeletal Disord 2013; 14: 292-302. [CrossRef]
17. Stoller DW. Magnetic resonance imaging of the knee; meniscal degenerations and tears. In Stoller DW (ed): Magnetic Resonance Imaging in Orthopaedics & Sports Medicine. Ed. 2., New York, Lippincott Williams & Wilkins 1997; 257-62.
18. Potter HG, Linklater JM, Allen AA, Hannafin JA, Haas SB. Magnetic resonance imaging of articular cartilage in the knee. An evaluation with use of fast-spin-echo imaging. J Bone Joint Surg 1998; 80: 1276-84. [CrossRef]
19. Acebes JC, Sánchez Pernaute O, Díaz-Oca A, Herrero-Beaumont G. Ultrasonographic assessment of Baker's cysts after intra- articular corticosteroid injection in knee osteoarthritis. J Clin Ultrasound 2006; 34: 113117. [CrossRef]
20. Tschirch FT, Schmid MR, Pfirrmann CW, Romero J, Hodler J, Zanetti M.Prevalence and size of meniscal cysts, ganglionic cysts, synovial cysts of the popliteal space, fluid-filled bursae, and other fluid collections in asymptomatic knees on MR imaging. AJR Am J Roentgenol 2003; 180: 1431-6. [CrossRef]