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ORIGINAL ARTICLE

Is low dose radiotherapy an effective treatment for Baker's cyst?

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Abstract

Purpose Osteoarthritis of the knee is a common disease, often associated with a Baker's cyst. Besides osteoarthritis, also other joint pathologies of the knee can be causative for a Baker's cyst. Radiotherapy is known to be an effective treatment for osteoarthritis, with an anti-inflammatory effect. As the excessive production of synovia usually is associated with intraarticular inflammation, our hypothesis was that radiotherapy might positively influence the synovial production and reduce the volume of a Baker's cyst.

Materials and methods We performed a prospective trial, including 20 knees receiving radiotherapy for knee arthritis. Besides documentation of NRS (numeric rating scale), WOMAC (Western Ontario and McMaster Universities Osteoarthritis Index) score and Knee Society Score, the volume of the Baker's cyst was calculated for a short- (6 to 12 weeks) and long-term (9 to 12 months) follow-up. Ultrasonic volumetry was performed using an ultrasound device with a high-resolution multifrequency linear probe (6–9 MHz).

Results Low-dose radiotherapy improved NRS, WOMAC score and Knee Society Score significantly. The mean volume of Baker's cyst decreased from 22.3 ml to 10.7 respectively 3.1 ml during follow-up. A decrease in volume of more than 25% compared to the baseline could be achieved for 75% of the patients in the short-term and 79% of the patients in the long-term follow up.

Conclusion Radiotherapy of knee osteoarthritis is an effective treatment that decreases the volume of a Baker's cyst. Most patients respond to the treatment. Whether radiotherapy is an effective treatment for Baker's cyst without associated osteoarthritis has to be further examined.

Keywords Knee arthritis · Osteoarthritis of the Knee · Baker's cyst · Popliteal cyst · Radiotherapy

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Ist die Strahlentherapie eine effektive Behandlungsoption der Bakerzyste?

Zusammenfassung

Hintergrund Die Gonarthrose ist eine der häufigsten degenerativen Erkrankungen, oft kombiniert mit einer Baker-Zyste. Baker-Zysten können auch bei anderen Erkrankungen des Kniegelenks auftreten. Die Strahlentherapie wirkt antiinflammatorisch und stellt eine effektive Therapieoption bei Gonarthrose dar. Da eine Bakerzyste in der Regel durch eine intraartikuläre Entzündungsreaktion bedingt ist, war unsere Hypothese, dass durch eine Strahlentherapie auch eine Bakerzyste effektiv behandelt werden kann.

Material und Methode Wir schlossen 20 Gelenke, bei denen die Durchführung einer Strahlentherapie geplant war, in eine prospektive Beobachtungsstudie ein. Neben der strukturierten Dokumentation der NRS (numerische Ratingskala), des WOMAC(Western Ontario and McMaster Universities Osteoarthritis Index)-Scores und Knee-Society-Scores erfolgte eine Volumetrie der Baker-Zyste in der kurzfristigen und langfristigen Nachsorge. Die Volumetrie der Baker-Zyste erfolgte durch Ultraschall unter Einsatz einer hochauflösenden Linearsonde (6–9 MHz).

Ergebnisse Die Patienten sprachen sowohl bezogen auf die NRS, als auch bezogen auf den WOMAC- und Knee-Society-Score auf die Bestrahlung an. Das Volumen der Baker-Zyste reduzierte sich im Mittel von 22,3 auf jeweils 10,7 bzw. 3,1 ml. Eine Volumenreduktion größer 25% konnte kurzfristig bei 75% bzw. langfristig bei 79% der Patienten erreicht werden.

Schlussfolgerung Die Strahlentherapie stellt eine effektive Behandlung sowohl hinsichtlich der Symptome einer Gonarthrose als auch hinsichtlich der Volumenreduktion einer begleitenden Baker-Zyste dar. Die Mehrzahl der Patienten profitiert von der Bestrahlung. Ob auch Baker-Zysten ohne begleitende Gonarthrose mit einer Strahlentherapie erfolgreich behandelt werden können, sollte weiter untersucht werden.

Schlüsselwörter Gonarthrose · Kniegelenksarthrose · Baker-Zyste · Popliteale Zyste · Strahlentherapie

Introduction

Osteoarthritis of the knee is a common disease, especially in elderly people. The prevalence is about 6.0% among the adult population [1, 2]. For the population older than 70 years, the prevalence is about 40% [1, 2]. Often an activated knee arthritis is associated with a Baker's cyst [3]. Besides activated/symptomatic knee arthritis, there are several other knee pathologies (e. g. rheumatoid arthritis, meniscus injury) which can be associated with a Baker's cyst [3]. A population-based cohort of persons aged 45 to 64 years showed a Baker's cyst to be prevalent in 31% in MRI screening [3]. The popliteal cyst was present in 23 to 32% of the population without and 40% of the population with symptomatic osteoarthritis [3, 4]. Usually a Baker's cyst is associated with any kind of coexistent joint pathology [1, 4]. In most cases the underlying knee pathology is associated with local intraarticular inflammation, increasing the production of synovial fluid [5, 6]. At the weakest point of the articular capsule—lateral of the semimembranosus muscle and medial of the gastrocnemius muscle—the so-called Baker's cyst or popliteal cyst will occur. Often the cyst fills big parts of the popliteal space. Symptoms may arise from the popliteal cyst itself or be dominated by the coexisting joint pathology [4, 7].

Patients are often limited by the symptoms referring to the Baker's cyst itself. Mainly they are handicapped by stiffness of the knee, swelling and a feeling of pressure [4]. Many patients with Baker's cyst are limited in their mobility [4].

Several therapeutic options for treatment of osteoarthritis of the knee as well as for popliteal cyst are in use. Besides arthroplasty and other joint replacing or conserving operations, there are several non-invasive therapy options (e. g. non-steroidal anti-inflammatory drugs, steroids) [2, 8]. The aims of the non-invasive treatment of osteoarthritis of the knee or Baker's cyst are pain relief, improvement of flexibility and mobility, as well as improvement of quality of life [2].

One effective non-invasive treatment for osteoarthritis of the knee is radiotherapy. Like for several other bone and joint disorders, low-dose radiation showed an anti-inflammatory effect [5, 6, 8–18].

Although a Baker's cyst can be commonly found in patients with osteoarthritis of the knee, the effect of the radiotherapy for a popliteal cyst hasn't been examined until now. As a Baker's cyst in adult patients is usually associated with intraarticular inflammation, the hypothesis of this survey was that anti-inflammatory radiotherapy of the knee might reduce the volume of a Baker's cyst and reduce the symptoms of the patients [6, 9].

Ultrasound is a well-established diagnostic and imaging modality for the knee joint [4, 7, 19]. It has been proven that, e. g. synovial hypertrophy or septations of a popliteal cyst can be assessed [7, 20]. Volumetry of Baker's cyst

is established and has been described in recent literature [19–23].

Patients and methods

This prospective study was approved by the Ethics Committee of the University of Regensburg.

Patients receiving radiotherapy for osteoarthritis of the knee and with palpable Baker's cyst were included in the study after giving informed consent. After inclusion, the measurability of the popliteal cyst with ultrasound was checked. If the volume of the cyst could be measured, the patients were kept in the study.

Patients receiving any other invasive therapy of the Baker's cyst, like, for example, puncture, resection of the cyst or arthroplasty, were excluded from the moment they received this invasive therapy. Those patients were calculated as non-responders for the continuing follow-up.

Pain was documented with the numeric rating scale (NRS). Evaluation of the NRS was done before and directly after each radiation therapy as well as for the entire follow-up. Follow-up was done 6 to 12 weeks (short-term follow-up) and 9 to 12 months (long-term follow-up) after treatment.

The WOMAC score (Western Ontario and McMaster Universities Osteoarthritis Index) as well as the objective part of the Knee Society Score was documented at baseline and for the entire follow-up [24, 25].

We used a high-end ultrasound device (LOGIQ E9, General Electrics, USA) with a multifrequency ultrasound probe (9L, 6–9 MHz, General Electrics, USA) for the ultrasound assessment. Before the volume of the Baker's cyst was measured, an entire sonographic examination of the knee was performed to detect additional knee effusions or other pathological findings. Relevant differential diagnoses of the Baker's cyst, e. g. a popliteal artery aneurysm or deep vein thrombosis, were ruled out. The volume of the Baker's cyst was given in millilitre (ml).

We performed radiotherapy with a linear accelerator (Primus [Siemens, Erlangen, Germany] and Synergy [Elekta, Stockholm, Sweden]) using 6 MV or 15 MV photons in opposing fields. Dose calculation was done to the isocentre. Knees were treated with a single dose of 0.5 Gy (8 knees) to a total dose of 3.0 Gy, or with a single dose of 1.0 Gy (12 knees) to a total dose of 6.0 Gy. In the majority of cases, the treatment time was 2 weeks (median 13 days, IQR 12 to 14 days).

We recorded descriptive statistics, calculated median, range and interquartile range (IQR) of NRS, the volume of the Baker's cyst, WOMAC score and Knee Society Score at baseline and for the entire follow-up.

A response was assumed if NRS lowered for at least one degree, if WOMAC score improved by at least 240 points (10%) and the objective part of the Knee Society Score improved by at least 10 points (10%).

A response was assumed if the volume of the Baker's cyst showed a reduction of at least 25% compared with the baseline. We defined complete response if the volume of the remaining popliteal cyst was less than 1 ml.

To analyse significant differences in the chronological sequence of NRS, the paired Wilcoxon test for dependent variables was used. The Mann–Whitney U test for independent variables was used for subgroup analyses and the Fisher–Yates test or chi^2-test for testing of binomial variables. We postulated that $p < 0.05$ was significant. Statistical analyses were performed with IBM SPSS Statistics 23.0.

Results

20 patients were included in the study. Due to loss of follow-up or a non-measurable cyst, 2 patients had to be excluded from the analysis. In total, 20 knees could be examined, due to the fact that two patients received radiotherapy of both knees synchronously or sequentially.

As patients were excluded from the moment they received any other invasive therapy of the popliteal cyst and due to loss of follow-up, we could not record long-term results of all patients.

The median age of the patients was 65 years, with a range from 53 to 80 years and an IQR from 59 to 75 years. 12 of the patients were female and 6 male. 8 left knees and 12 right knees were treated. All patients had received other treatment for knee arthritis before, with a mode of 3.

6 knees were treated with two courses of radiotherapy, mostly within a 6- to 12-week interval after the initial radiation courses (Table 1).

Acute or long-term side effects did not occur in our sample.

The median pain before irradiation was 6.5 on the NRS (IQR 5 to 7). At the short-term follow-up the median was 3 (IQR 1 to 6) and at the long-term follow-up it was 2 (IQR 1 to 7.5) (Table 2).

The response rate for NRS was 72% for the short-term and 60% for the long-term follow-up (Fig. 1).

Pain reduction compared with the pain level before irradiation was significant, with $p < 0.005$ for the short-term follow-up. Comparing median NRS level before irradiation with the one at long-term follow-up, there was a tendency for pain reduction ($p = 0.05$).

At the short-term follow-up 80% and for the long-term follow-up 56% of the patients on analgesic medication at baseline could reduce this medication.

Table 1 Demographic data

Criteria	
Patients (n)	18
Knees (n)	20
Gender (n)	
Male	6
Female	14
Age (years)	
Median	65
First quartile	59
Third quartile	75
Sites (n)	
Right	12
Left	8
Single dose (n)	
0.5 Gy	8
1.0 Gy	12
Total dose	
3.0 Gy	8
6.0 Gy	12
Pre-treatment beside radiation (%)	100%
Number of modalities (n)	
Median	4
Mode	3
Number of radiation courses (n)	
One course	14
Two or more courses	6

The objective part of the Knee Society Score was 49 in median (IQR 39 to 71) at baseline, 65 (IQR 42 to 89) for the short-term and 70 (50 to 97) for the long-term follow-up.

The response rate for the Knee Society Score was 67% for the short-term and for the long-term follow-up. There was a significant improvement in terms of the objective part of the Knee Society Score for the short-term follow up ($p = 0.008$).

The WOMAC score was median 1240 (IQR 1190 to 1450) at baseline, 730 (IQR 50 to 1200) for the short-term and 550 (440 to 780) for the long-term follow-up.

The response rate for WOMAC score was 80% for the early and 89% for the late follow-up. There was a significant improvement due to the WOMAC score for the short-term and long-term follow-up ($p < 0.012$) (Fig. 1).

For the stiffness part of the WOMAC score, the baseline was median 110 (IQR 90 to 180). For the short-term it was 80 (IQR 30 to 110) and for the long-term follow-up 60 (IQR 50 to 80).

For the function part of the WOMAC score the baseline was median 910 (IQR 800 to 1020). For the short-term it was 530 (IQR 20 to 880) and for the long-term follow-up 400 (IQR 260 to 590). There was a significant improvement in terms of function for the entire follow-up ($p < 0.05$) as well as for stiffness for the long-term follow-up ($p < 0.05$). There was just a tendency toward improvement in terms of stiffness for the short-term follow-up ($p = 0.056$).

The mean Baker's cyst volume was 22.3 ml at baseline (standard deviation 27.5 ml), 10.7 ml (17.0 ml) for the early and 3.1 ml (4.6 ml) for the late follow-up. The response rate was 75% for the early and 79% for the late follow-up.

There was a significant decrease in volume for the early and late follow-up ($p < 0.005$; Tables 2 and 3; Figs. 2 and 3).

A complete response (remaining volume of popliteal cyst <1 ml) could be identified in 35 and 43% of the patients for the short- and long-term follow-up, respectively (Table 3).

There was neither a significant correlation between decreasing volume and improvement of NRS ($chi^2 < 1.0$) nor a significant correlation between decreasing volume and improvement of WOMAC or Knee Society Score ($chi^2 < 3.5$) for the entire follow-up.

There was no significant correlation between complete response in terms of the volume of the popliteal cyst and improvement of NRS, WOMAC or Knee Society Score ($chi^2 < 3.5$).

We could not find a correlation between decreasing or complete response of the Baker's cyst and parts of the WOMAC score (stiffness part and function part, $chi^2 < 3.5$).

Discussion

Our study is the first in which radiotherapy of a popliteal cyst has been systematically examined. An anti-inflammatory effect of radiotherapy in arthritis of the knee has been detected, but the relevance in daily clinic has only been proven in terms of improvement of pain and improvement of different osteoarthritis scores [14, 15, 26].

As a Baker's cyst in adults is usually associated with intraarticular inflammation leading to increased synovial fluid production, the hypothesis of our survey was that anti-inflammatory radiotherapy might decrease the volume of a Baker's cyst.

We only included patients for whom radiotherapy of knee osteoarthritis was indicated anyway.

Ultrasound examinations were performed by two experienced investigators only. The reason was to minimize discrepancies, because the results of sonography are dependent on the investigator to a certain degree [27, 28].

To minimize the effect of measuring inaccuracy, we defined a response as a decrease in volume of at least 25%.

We defined a complete response as a non-existent Baker's cyst or a residual cyst of less than 1 ml. Despite very good regression, it cannot be expected that no residuum of the overstretched articular capsule can be detected.

Table 2 Follow-up data

Criteria	Baseline	Short-term follow-up	Long-term follow-up
NRS			
Median	6.5	3	2
First quartile	5	3	1
Third quartile	7	6	7.5
Knee Society Score (points)			
Median	49	65	70
First quartile	39	42	50
Third quartile	71	89	97
WOMAC score (points)			
Median	1240	730	550
First quartile	1190	50	440
Third quartile	1450	1200	780
WOMAC score (stiffness part)			
Median	110	80	60
WOMAC score (function part)			
Median	910	530	400
Cyst volume (ml)			
Average	22.3	10.7	3.1
Standard deviation	27.5	17.0	4.6
Median	14.3	5.9	0
First quartile	6.9	0.6	0
Third quartile	26.4	16.9	5.5

NRS numeric rating scale

Table 3 Response data

Criteria	Short-term follow-up (p-value)	Long-term follow-up (p-value)
NRS		
General response	72% ($p < 0.005$)	60% ($p = 0.05$)
Complete response (NRS 0 or 1)	33%	30%
Knee Society Score		
General response	67% ($p < 0.008$)	67% ($p = 0.068$)
WOMAC score		
General response	80% ($p < 0.015$)	89% ($p < 0.012$)
Cyst volume		
General response	75% ($p = 0.002$)	79% ($p = 0.003$)
Complete response	35%	43%

NRS numeric rating scale

Altogether, these criteria are tight, but we chose this concept to minimize the acceptance error.

We found that most of the patients had a decrease in the volume of the Baker's cyst. In 75% of the patients, the volume of the cyst decreased for at least one quarter in the short-term follow-up. 35% of the patients had a complete response of the Baker's cyst.

Besides that, there was a significant reduction in the median/mean volume of the cysts.

For the long-term follow-up we still found a significant decrease in the volume of the popliteal cysts. In 79% of the patients the volume of the cyst had improved by at least one quarter due to our definition of response. It must be considered that some patients were calculated as non-responders even if the cyst had decreased at the short-term follow-up. But as the patients received an invasive treatment of the popliteal cyst or the osteoarthritis (most of the time puncture of the cyst or an arthroplasty of the knee), they were non-responders due to our definition.

Nevertheless, 43% of the patients showed a complete response in the long-term follow-up.

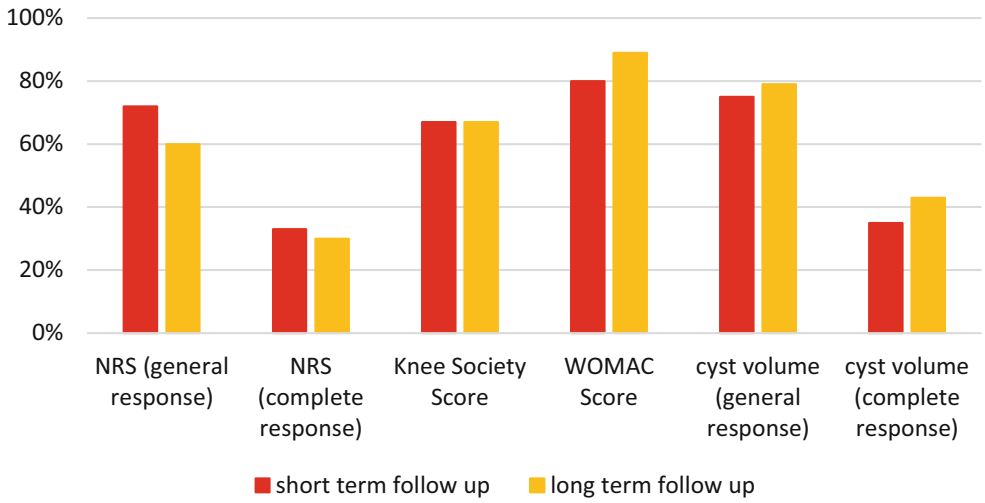

Fig. 1 Response rates of short-term and long-term follow-up for NRS, Knee Society Score, WOMAC score and cyst volume

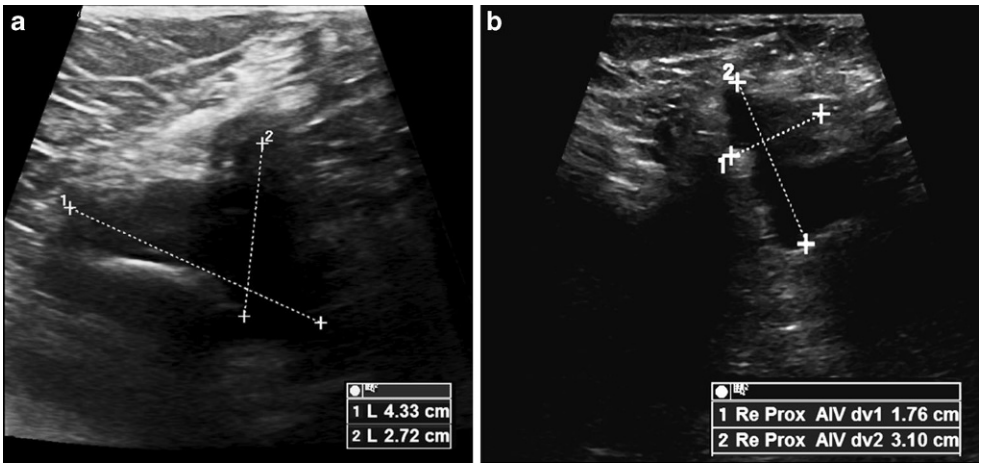

Fig. 2 Partial regression of a Baker's cyst 12 weeks after low-dose radiotherapy

The median/mean volume of the cyst could only be measured for the patients not receiving a puncture of the Baker's cyst or an arthroplasty of the knee.

Recent literature shows comparable results for intraarticular steroid injections, with decreases between 58 and 100% [4, 21–23, 29]. It has to be noted that in many surveys, synovial fluid was aspirated before instillation of steroids [4, 22, 23].

Systemic therapy with non-steroidal anti-inflammatory drugs or steroids has lower response rates and is usually only used if rheumatoid arthritis is causative for the cyst [4, 30].

Topical drug therapy, for example with non-steroidal anti-inflammatory drugs or topic cold therapy, shows low response rates [30].

It must be considered that intraarticular injection has a risk of septic arthritis. Even the risk is low, with around 9.2 per 100,000, the consequences are often dramatic [31]. There is a relevant risk of complications due to drug therapy with non-steroidal anti-inflammatory drugs or steroids. Especially renal, gastric and cardiac complications have been described [32, 33].

The risk of anti-inflammatory radiotherapy to the knee is extremely low. Relevant acute side effects did not occur in published literature. The risk of tumour induction can be calculated and is around 0.1% for radiotherapy of a knee joint in an average patient [34].

All patients enrolled in our survey had received several other treatments for knee arthritis or Baker's cyst in the past and did not respond well to these therapies. It can be assumed that our sample is a negative selection.

There is a high risk of recurrence after resection of Baker's cyst. It is recommended only for refractory cysts after several non-surgical treatments [4, 30, 35]. Arthroplasty is an effective treatment for Baker's cyst, but of course without joint preservation, and indicated for patients with severe osteoarthritis of the knee.

Beside the results of the volumetry, also NRS, WOMAC score and Knee Society Score improved after radiotherapy. Due to loss of follow-up and exclusion of patients from the survey (because they received an invasive treatment of

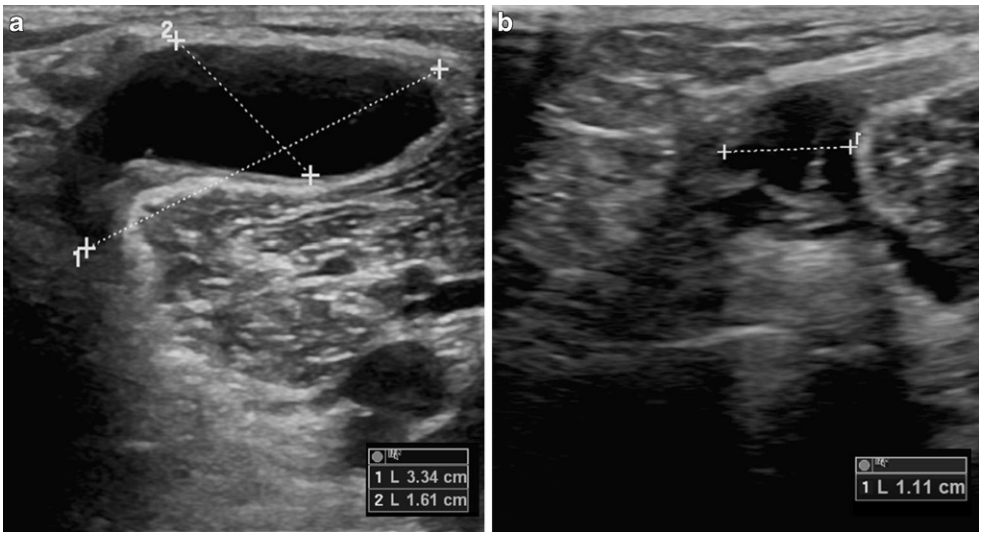

Fig. 3 Good regression of a Baker's cyst at long-term follow-up

Baker's cyst or osteoarthritis of the knee), we couldn't gain all information for the long-term follow-up. This might be one reason why we could find a significant improvement of the pain as well as in the different scores for the short-term follow-up but not for the long-term follow-up.

A significant correlation between NRS, WOMAC score, the objective part of the Knee Society Score and the function part and stiffness part of the WOMAC score on the one hand and volumetric response of Baker's cyst on the other hand couldn't be detected. We found a tendency towards a correlation between the WOMAC score or parts of the WOMAC score and a complete response of the cyst for the entire follow-up, and between the Knee Society Score or WOMAC score and the volumetric response of the cyst for the long-term follow-up. There might be several reasons for this non-significance:

First, the vast majority of patients responded to radiotherapy. The group of non-responders was very small.

Secondly, we could not analyse the scores of all patients for the entire follow-up. Sometimes patients did not answer a certain question, so that the whole score could not be calculated.

Furthermore, due to the fact that some patients had to be excluded from the study before they reached the time for long-term follow-up, we are missing the information on the scores of these patients.

The symptoms could also be caused by the osteoarthritis itself, not by the Baker's cyst.

Many patients had polyarthrosis. It might be that it was difficult for the patients to differentiate whether reduction of the WOMAC score was due to knee arthritis or polyarthrosis.

Lastly, the whole sample was not notably large, and we lost some patients to follow-up.

Anyhow, the described tendency could give the idea that volumetric response of a popliteal cyst might improve function (due to the function part of the WOMAC score) and stiffness (due to the stiffness part of the WOMAC score and the objective part of the Knee Society Score) of the knee.

A further investigation of the impact of radiotherapy on Baker's cyst in a larger collective and of the impact of radiotherapy on Baker's cyst without association with osteoarthritis of the knee would seem interesting.

Nevertheless, our results permit the treatment of Baker's cyst with anti-inflammatory radiotherapy.

Conclusion

Radiotherapy of osteoarthritis of the knee is an effective treatment. Baker's cysts can be decreased in volume by anti-inflammatory radiotherapy, which can lead to complete response in several cases.

Compliance with ethical guidelines

Conflict of interest M.G. Hautmann, E.-M. Jung, L.P. Beyer, C. Süß, F. Steger, M. Weber, F. Pohl, O. Kölbl and F.J. Putz declare that they have no competing interests.

Ethical standards This prospective study was approved by the Ethics Committee of the University of Regensburg.

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