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Treatment of septic arthritis of the knee: a comparison between arthroscopy and arthrotomy

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Abstract
Purpose The aim of this study was to compare the efficacy of arthroscopy and arthrotomy in patients with septic monarthritis of the knee.
Methods Seventy consecutive patients who underwent surgery because of a bacterial monarthritis were evaluated. Patients were either treated with arthroscopy or with arthrotomy. Our primary outcome was the early recurrence of infection (>3 months after surgery), which made a second surgical procedure necessary. Furthermore, the influence of potential confounders on treatment outcome was analysed.
Results Of the 70 patients, 41 were treated arthroscopically and 29 with arthrotomy. Eight patients (11.4 %) had to undergo a second surgical procedure because of early re-infection. The rate was significantly higher in patients treated with arthrotomy ($n = 6$; 20.7 %) compared with those treated by arthroscopy ($n = 2$) ($p = 0.041$). Range of motion was significantly better in patients who underwent arthroscopy ($p < 0.001$). Male sex had negative influence on the treatment success ($p = 0.03$).
Conclusions Patients with bacterial monarthritis of the knee who were treated with arthroscopy had a significantly lower re-infection rate and a better functional outcome than those treated with arthrotomy. As arthroscopy is the less invasive method, it should be considered the routine treatment, according to our data.
Level of evidence Therapeutic study, Level III.

Keywords Septic monarthritis · Knee · Treatment · Arthroscopy · Arthrotomy

Introduction

Septic arthritis is a therapeutic emergency with a mortality rate of approximately 10 % [9]. The incidence of bacterial joint infection in Western Europe is around 4–10 per 100,000 patients per year, and it appears to be increasing [7, 12, 17, 18, 28]. The knee is the most often affected joint and is involved in about 50 % of the cases [28].

Infections of the knee can occur either after haematogenous spread or directly due to local trauma or a medical intervention. Several risk factors such as osteoarthritis, immunosuppression, ageing, diabetes mellitus, rheumatoid arthritis, alcoholism, intravenous drug abuse and previous intra-articular corticosteroid injection have been described so far [9, 12, 16]. The most frequently found bacteria is *Staphylococcus aureus* (*S. aureus*), followed by streptococci and other gram-positive bacteria [5, 6, 11, 12]. Patients with bacterial arthritis require immediate medical care, as inadequate and delayed treatment can cause permanent joint damage. The management of the septic arthritis includes prompt antibiotic treatment as well as joint decompression and removal of purulent material of the affected joint [4]. Therefore, conservative measures such as closed-needle aspiration and surgical interventions as arthroscopy with lavage with or without debridement as well as open arthrotomy together with (sub-) total synovectomy have been discussed for treatment [8, 16, 21, 25–27, 29]. While needle aspiration should be only performed at the early stages of infection [2], there is little evidence to show which surgical intervention is best and there are no clear treatment recommendations available. Only a few

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studies have examined this topic [2, 15, 23, 29]. The purpose of this study was to compare efficacy of arthroscopic debridement and arthrotomy with regard to infection eradication in patients with septic monarthritis of the knee. The primary outcome goal was the early recurrence of infection, which was determined at 3 months after surgery. Secondarily, the range of motion after therapy was compared and the influence of potential confounders on treatment success was analysed. It was hypothesized that one therapy option is superior to the other and should be recommended as standard treatment.

Materials and methods

Data were collected retrospectively from consecutive patients who underwent surgery at our clinic for bacterial monarthritis of the knee between 2002 and 2010. Patients presenting typical clinical symptoms (a hot, swollen joint, with restricted mobility), an isolated joint affection, purulent synovial fluid, elevated inflammatory markers, without any implant, who were treated either by arthroscopy or by arthrotomy were included to the study. In total the medical records from ninety-two patients with suspected septic arthritis were available. Patients were excluded when the diagnosis was not confirmed either by a positive culture of the joint fluid or by histopathological examination. Furthermore, when osteomyelitis of the distal femur or the proximal tibia was present or cultures were positive for mycobacteria, fungus or gonococcus, the patients were excluded. The remaining seventy consecutive patients were included in the final analysis (Fig. 1 depicts the detailed exclusion process).

Examination

All patients underwent pre-treatment joint aspiration, and bacteriological samples were taken, as well as blood examination including blood culture. Demographical data, medical history and co-morbidities were recorded. Co-morbidities were summarized by the Charlson co-morbidity index (CCI) [3]. Furthermore, inflammatory blood parameters such as C-reactive protein (CRP, in mg/dl) and white blood cell (WBC, in G/l) count were noted. Range of motion (ROM) was determined before and after surgery. For post-operative ROM, data from the latest available examination have been chosen. Radiographs of the affected knee were performed in all cases, and the Kellgren and Lawrence classification was used to determine the osteoarthritis radiological grade from 0 to IV. [13]. The cartilage damage was graded 0–IV by the Outerbridge classification [19] and the inflammatory process I–IV by Gächter's classification [24]. Additionally, days of hospitalization were recorded.

Treatment

Intravenous antibiotic therapy was started during operation immediately after retrieval of at least two aspiration specimens. In general, patients received cefazolin, except those who were allergic to penicillin and/or cephalosporins. These were treated with clindamycin. Antibiotics were then adapted dependent on culture results and antibiogram, and if necessary in consultation with the department of infectious diseases. Routinely, we continued antibiotic therapy for 6 weeks after surgery and changed to an oral medication after discharge.

Forty-one patients were treated with arthroscopy, and 29 underwent open arthrotomy. According to his personal preference, a consultant orthopaedic surgeon took the decision about the type of surgery. Both surgical procedures included sampling for microbiological and histopathological examination, joint irrigation with saline, and synovectomy and debridement, depending on the surgeon's evaluation. At least one suction drain was employed and usually left for 5 days. Active and passive motion training was started between 1 and 4 days after operation with partial weight bearing. Continuous passive motion devices were used in the majority of our cases. The use of crutches was recommended for 4–6 weeks, and partial weight bearing was allowed. Patients were routinely seen after discharge in the outpatient clinic. The median (25th/75th percentile) follow-up time for assessment was 12 months (10/15). Clinical examination, radiographs and blood testing were performed at that time. All participants gave their informed consent for anonymous analysis of their data, and the study was approved by the ethics committee of the Medical University of Vienna (identification number 2011/710).

Statistical analysis

Chi-squared test was used to compare the re-infection rate of patients treated by arthroscopy and arthrotomy. Moreover, we investigated differences according to the presence of potential confounders between the two surgery groups and also between patients for whom primary infection eradication could be achieved and for whom a second surgical intervention was necessary. Here, we used Mann–Whitney U test and also Chi-squared test. Furthermore, the ROM before and after surgery was evaluated, and again paired t test and Wilcoxon test to compare the outcome and the two surgical techniques were used. Since this was a retrospective study, the achievable sample size was fixed based on the available cases between 2002 and 2010. With the number of identified cases, post hoc power analyses revealed a statistical power of 98.2 % for calculation of differences concerning the post-operative ROM. Continuous variables were described by median (25th/75th percentile) when appropriate. Values of $p < 0.05$ were considered as statistically significant. Additionally, a descriptive statistic

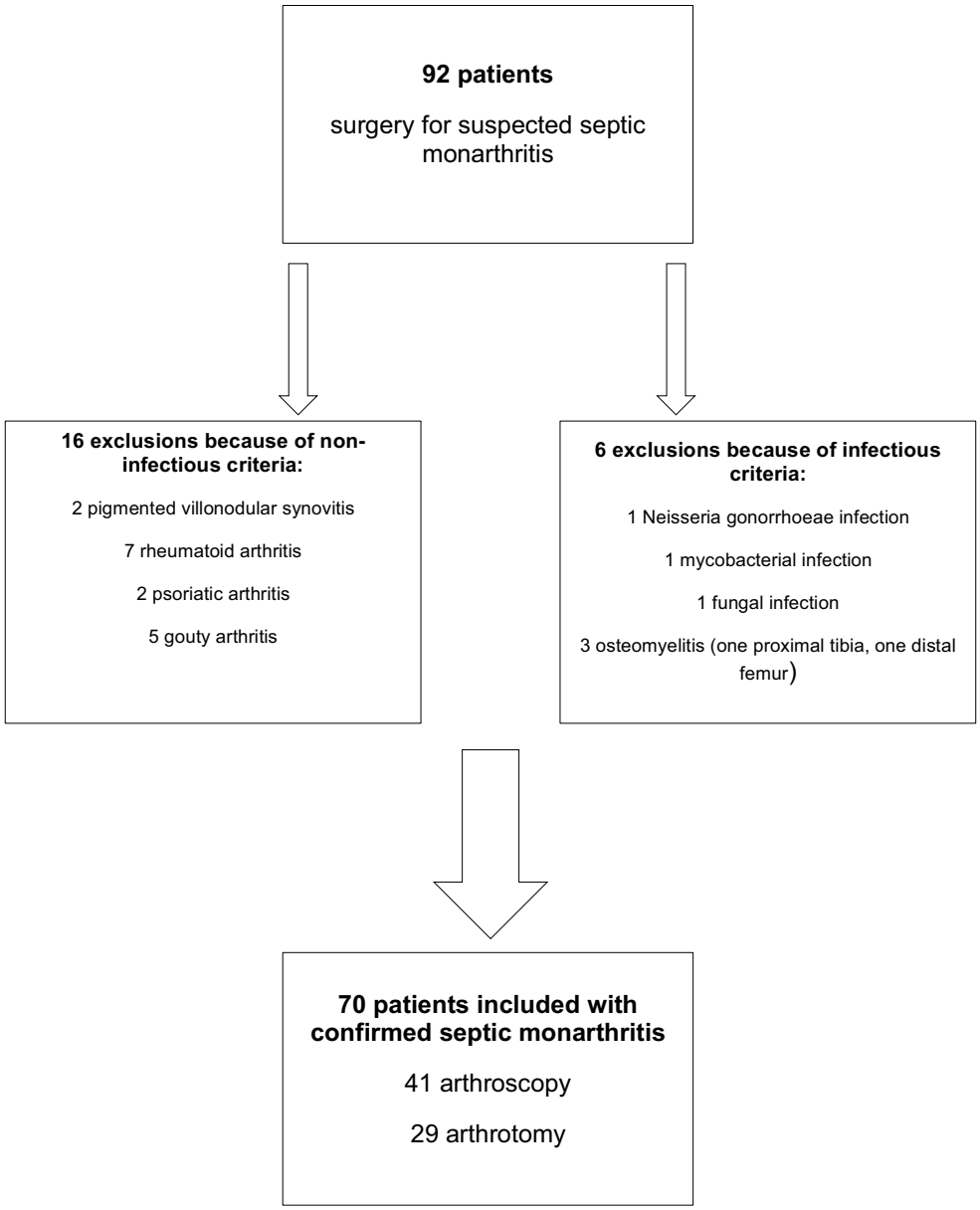

Fig. 1 Flow-chart diagram of the exclusion process

assessment was performed. IBM SPSS Version 20 was used for all statistical analysis.

Results

Seventy patients were included in the current study. Forty one (58.6 %) were treated arthroscopically and 29 (41.4 %) underwent open arthrotomy. Table 1 summarizes the patient characteristics. A recurrence of infection within 3 months after surgery, which made a second surgical procedure necessary, was seen in eight (11.4 %) of 70 patients. Differences between patients who suffered re-infection and those with successful index surgery are summarized in Table 2. The re-infection rate was significantly higher in the arthrotomy group than in the arthroscopy group ($p = 0.041$). Six (20.7 %) out of 29 patients treated by open arthrotomy and two out of 41 patients treated with arthroscopy developed re-infection. Differences between the arthroscopy and the arthrotomy group are provided in Table 1.

As the two treatment groups differed significantly from each other regarding age and co-morbidities, we performed age-adjusted subgroup analysis to diminish the potential influence of these confounders on the results. Therefore, we selected the second and third age percentile of our cohort and repeated analysis. In total 36 patients were included in

Table 1 Patient characteristics and differences between arthroscopy and arthrotomy group (*$p \leq 0.05$)

	Total	Arthroscopy	Arthrotomy	*p* value
Female *n* (%)	24 (34.3 %)	14 (34.1 %)	10 (34.5 %)	n.s.
Age	59 (36/72)	49 (30/64)*	71 (65/78)*	<0.001
Weight (kg)	77 (63/88)	74 (59/89)	80 (69/88)	n.s.
Height (cm)	171 (165/178)	171 (165/180)	170 (163/176)	n.s.
BMI	26.1 (23.1/29.2)	25.4 (22.4/28.6)	27.2 (24.4/30.3)	n.s.
Hospitalization (days)	10 (7/16)	9 (7/12)*	14 (8/20)*	0.02
Duration of symptoms (days)	4 (3/7)	4 (2/7)	6 (3/11)	n.s.
CCI	4 (1/6)	2 (0/4)*	5 (4/7)*	<0.001
Rheumatoid arthritis *n* (%)	4 (5.7 %)	4 (9.8 %)	0	n.s.
Diabetes mellitus *n* (%)	17 (24.3 %)	7 (17.1 %)	10 (34.5 %)	n.s.
CRP pre-surgery (mg/dl)	14.9 (8.2/21.4)	14.8 (7.5/21.3)	16.3 (9.6/23.2)	n.s.
WBC count pre-surgery (G/l)	11.6 (8.1/13.5)	11.5 (8.4/12.9)	11.7 (6.9/14.4)	n.s.
CRP post-surgery (mg/dl)	8.3 (3.1/12.5)	6.4 (1.5/10.1)	10.3 (5.5/12.8)	n.s.
WBC count post-surgery (G/l)	9.5 (6.4/10.7)	8.9 (5.4/10.1)	9.8 (7.4/10.8)	n.s.
Gächter *n* (%)				
I	9 (16.7 %)	7 (23.3 %)	2 (8.3 %)	n.s.
II	31 (57.4 %)	19 (63.3 %)	12 (50 %)	
III	12 (22.2 %)	4 (13.3 %)	8 (33.3 %)	
IV	2 (3.7 %)	0	2 (8.3 %)	
Kellgren and Lawrence *n* (%)		*	*	0.013
0	12 (25 %)	11 (39.3 %)	1 (5 %)	
I	10 (20.8 %)	7 (25 %)	3 (15 %)	
II	16 (33.3 %)	7 (25 %)	9 (45 %)	
III	10 (20.8 %)	3 (10.7 %)	7 (35 %)	
IV	0	0	0	
Outerbridge *n* (%)				n.s.
0	10 (23.3 %)	9 (33.3 %)	1 (6.2 %)	
I	11 (25.6 %)	8 (29.6 %)	3 (18.8 %)	
II	8 (18.6. %)	5 (18.5. %)	3 (18.8. %)	
III	8 (18.6 %)	2 (7.4 %)	6 (37.5 %)	
IV	6 (14 %)	3 (11.1 %)	3 (18.8 %)	

Except where indicated otherwise, values presented are median (25th percentile/75th percentile)

the subanalysis. In this subgroup patients were between 36 and 72 years old with a median age of 59 years. Table 3 summarizes results of the age-adjusted subgroup analysis. In six (16.7 %) of the cases a re-infection occurred. Also in the subgroup examination the re-infection rate was significantly higher in the arthrotomy group compared with the arthroscopy group ($p = 0.032$). However, CCI, age and the Kellgren and Lawrence classification differed no longer between the surgery groups.

Functional results

Overall ROM did not differ significantly before [95 (70/110)] and [100 (90/110)] after the surgical intervention. The results differed as we compared ROM pre- and post-surgically separately for the arthrotomy and the arthroscopy group. ROM improved significantly in patients who underwent arthroscopy ($p = 0.012$), whereas there was no functional improvement in the arthrotomy group. While in the pre-surgical examinations there was no difference between the groups, the functional outcome was significantly better in patients following an arthroscopy ($p < 0.001$). Results of the functional outcome are shown in Fig. 2. When we repeated the analysis in the age-adjusted subgroup, post-operative outcome was still significantly better in the arthroscopy group ($p = 0.008$) (see also Table 3).

Discussion

The most important findings of the present study were the significantly lower re-infection rate and the significantly better functional outcome in patients treated by

Table 2 Differences between primary eradication group and re-infection group (*$p \leq 0.05$)

	Primary eradication	Re-infection	*p* value
Female *n* (%)	24 (100 %)*	0*	0.03
Age	57 (34/72)	65 (48/74)	n.s.
BMI	26.2 (23.1/29.2)	25.4 (24.6/32.5)	n.s.
Hospitalization (days)	10 (7/14)*	24 (11/48)*	0.004
Duration of symptoms (days)	4 (2/7)	7 (5/7)	n.s.
CCI	4 (0/5)	6 (2/7)	n.s.
Rheumatoid arthritis *n* (%)	4 (6.5 %)	0	n.s.
Diabetes mellitus *n* (%)	14 (22.6 %)	3 (37.5 %)	n.s.
CRP pre-surgery (mg/dl)	14.9 (8.2/21.4)	14.7 (6.9/23.4)	n.s.
WBC count pre-surgery (G/l)	11.8 (9.2/13.5)	6.8 (6.1/13.5)	n.s.
CRP post-surgery (mg/dl)	8.7 (2.8/12.4)	8.2 (5.7/15.6)	n.s.
WBC count post-surgery (G/l)	9.3 (6.1/10.6)	11.4 (10.5/12.8)	n.s.

Table 3 Differences between treatment groups after adjustment for age

	Arthroscopy	Arthrotomy	*p* value
N (%)	20 (55.6 %)	16 (44.4 %)	
Re-infection *n* (%)	1*	5 (31.2 %)*	0.036
Female *n* (%)	8 (40 %)	10 (34.5 %)	n.s.
Age (years)	57 (51/65)	60 (54/69)	n.s.
BMI	26.6 (23.7/30.8)	28.3 (24.8/33.9)	n.s.
Hospitalization (days)	10 (8/11)	11 (8/21)	n.s.
Duration of symptoms (days)	4 (2/7)	4 (3/7)	n.s.
CCI	4 (2/5)	4 (3/7)	n.s.
CRP pre-surgery (mg/dl)	14.9 (5.9/20.2)	16.3 (9.1/24.2)	n.s.
WBC count pre-surgery (G/l)	12.2 (10.5/14.2)	11.6 (6.8/14.5)	n.s.
CRP post-surgery (mg/dl)	9.5 (3.2/13.1)	10.3 (5.5/14.5)	n.s.
WBC count post-surgery (G/l)	9.3 (7.1/10.5)	10.7 (10.1/12.4)	n.s.
ROM pre-surgery (degrees)	100 (70/105)	90 (75/100)	n.s.
ROM post-surgery (degrees)	110 (108/125)*	95 (40/100)*	0.008
Gächter *n* (%)			n.s.
I	3 (20 %)	1 (7.1 %)	
II	9 (60 %)	8 (57.1 %)	
III	3 (20 %)	5 (37.7 %)	
IV	0	0	
Kellgren and Lawrence *n* (%)			n.s.
0	4 (25 %)	1 (11.1 %)	
I	5 (31.2 %)	0	
II	6 (37.5 %)	6 (66.7 %)	
III	1 (6.2 %)	2 (22.2 %)	
IV	0	0	
Outerbridge *n* (%)			n.s.
0	3 (21.4 %)	1 (9.1 %)	
I	5 (35.7 %)	2 (18.2 %)	
II	1 (7.1 %)	3 (27.3 %)	
III	2 (14.3 %)	3 (27.3 %)	
IV	3 (21.4 %)	2 (18.2 %)	

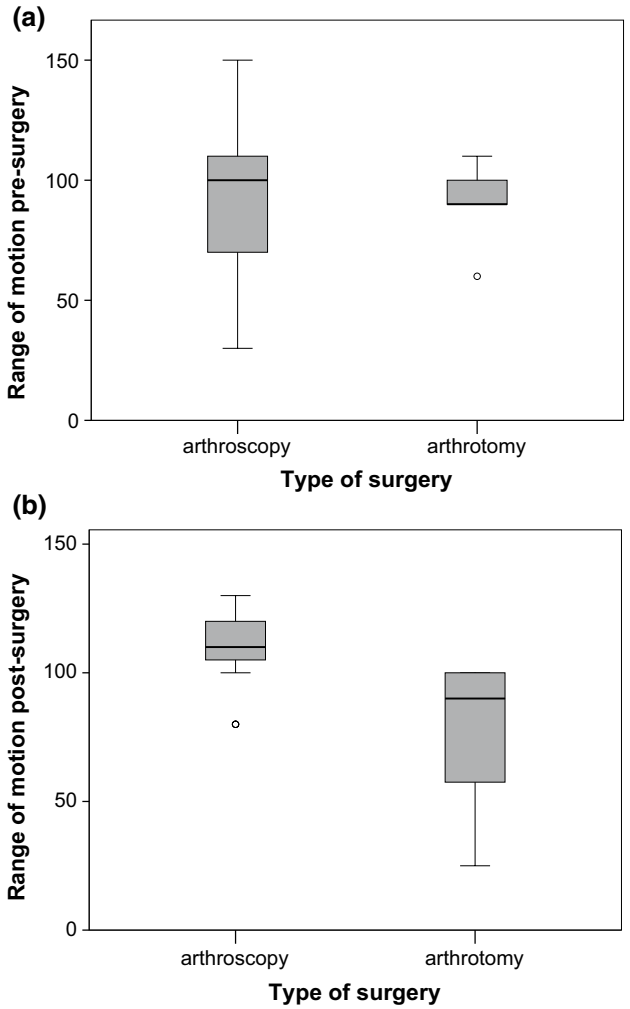

Fig. 2 Comparison between surgery types concerning range of motion. **a** Range of motion pre-surgical. **b** Range of motion post-surgical

arthroscopy compared with patients who underwent open arthrotomy. The treatment success rate of the arthroscopy group was 95 %, whereas in the arthrotomy group it was only 79 %. These findings are in line with a previous study, which compared the two surgery types. Balabaud et al. [2] described a significantly higher treatment success rate in patients treated with arthroscopy, but the effect was linked to a shorter delay in surgery. A study which compared open and arthroscopic treatment of septic arthritis of the wrist also found a significantly higher treatment success rate in the arthroscopy group [22]. Overall, the primary salvage rate after infection was about 89 % and is similar to results presented in the literature [1, 25, 27, 29]. Pre-surgical ROM did not differ between the groups. Physical function improved only significantly in patients who were treated arthroscopically, while patients in the arthrotomy group showed no better ROM after surgery. Wirtz et al. [29] described a higher improvement in the functional outcome in patients who underwent arthroscopy, but the differences did not reach significance. Smaller study populations and differences in study design might be the reason.

In the studied population, treatment success was significantly influenced by gender. In fact no female participant suffered re-infection. These findings are very interesting, as male and female patients neither differed concerning the presence of confounders nor in the frequency of the surgery type. So male sex might be an independent risk factor for septic monarthritis and re-infection. Former studies on this topic have not described an influence of gender on treatment success rate, but male sex has been detected to be a risk factor for infections following total joint arthroplasty [10, 14, 20]. In contrast to earlier studies, we found no influence of duration of symptoms before surgical intervention on treatment success [2, 15, 29].

In the presented cohort patients treated by arthrotomy were significantly older, suffered from more co-morbidities and had higher grades of osteoarthritis according to the Kellgren and Lawrence classification. Although these potential confounders had no significant influence on the re-infection rate, ageing, osteoarthritis and co-morbidities such as rheumatoid arthritis and diabetes mellitus among others have been described to be risk factors for septic arthritis [17]. In order to refine the compared groups, we selected patients between 36 and 72 years (second and third age percentile) and repeated the analysis. No more differences concerning confounders could be observed in this cohort, but still the re-infection rate was significantly lower and the functional outcome significantly better in the arthroscopy group. Thus, there seems to be an independent effect of the surgery type on the treatment success.

There is little evidence in the literature on the question of which type of surgery should be performed at which stage of infection. There seems to be a consensus that arthroscopy should be performed in Gächter's stage I and II. Balabaud et al. suggested treating patients with stage III with open arthrotomy, whereas Wirtz et al. recommended arthroscopy also in stage III, when inflammatory symptoms were present for <5 days. [2, 29] In the current cohort treatment success was neither influenced by Gächter's stage, nor by duration of symptoms. Regarding the lower re-infection rate and better functional outcome in the arthroscopy group in our study, we suggest treating patients arthroscopically up to Gächter's stage III. Concerning stage IV we had only two patients graded stage IV. Both were treated with open arthrotomy and did not suffer re-infection. Therefore, our data do not allow legitimate conclusions, but as grade IV is defined by osseous involvement, open arthrotomy with synovectomy and curettage seems to be indicated at this stage.

Some limitations of the current study have to be addressed. Firstly, data acquisition was conducted retrospectively, and therefore, no randomization was conducted. The decision on which surgery should be performed was made by a consultant orthopaedic surgeon depending on his personal preferences. Hence, the surgery groups were not homogenous and differed according age and presence of co-morbidities. With subgroup analyses we diminished the potential influence of these factors still found a significantly better outcome in the arthroscopy group. Secondly, although the number of included participants was higher than in other studies on this topic, the number of patients who suffered re-infection was low. Hence, the influence of some confounders, such as co-morbidities or osteoarthritis could have been underestimated in our analysis.

In summary, patients treated by arthroscopy showed a better functional outcome and a higher primary infection eradication rate. To the best of our knowledge, this is the first study, which could detect a significant independent effect of the type of surgery on the treatment success. For clinical purposes, the presented data suggest that septic monarthritis, besides immediate application of antibiotics, should be treated primarily by arthroscopic irrigation and when indicated by debridement. Open arthrotomy should be reserved for patients with infectious bone involvement.

Conclusion

Patients with septic arthritis of the knee treated by arthroscopy had a better functional outcome and a lower re-infection rate than patients who underwent arthrotomy. Moreover, male patients were at higher risk of developing recurrence of infection.

Conflict of interest The authors declare that they have no conflicts of interest.

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