Arthroscopic Versus Open Treatment for Acute Septic Arthritis of the Knee in Children

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Background: Acute septic arthritis of the knee in children may be treated by arthroscopic or open methods; however, pediatric data comparing these methods is limited regarding both short- and long-term outcomes. This study aimed to compare outcomes after arthroscopic versus open surgery for acute pediatric septic knee arthritis.

Methods: Pediatric patients with acute knee septic arthritis treated at our institution from 1996 to 2016 were retrospectively assessed. The clinical presentations, operations, microorganisms, laboratory results, knee radiologic findings and antibiotics administered were compared. Patients' long-term outcomes were assessed at mean 6.9 (range 1.1–20.3) years.

Results: Twenty-four patients met the inclusion criteria. Eleven patients received arthroscopic irrigation and 13 had open irrigation. Five patients in the open group (38.5%) required a second irrigation compared with none in the arthroscopic group [95% confidence interval (CI): 12%–65%; $P = 0.041$]. Time to range the knee occurred earlier in the arthroscopic group (5.0 days; arthroscopic vs. 10.6 days; open, difference 5.6 days: 95% CI: 0.84–10.3, $P = 0.023$), as well as weight-bearing (2.7 days; arthroscopic vs. 10.3 days; open, difference 7.6 days: 95% CI: 2.3–12.9, $P = 0.008$). Eighty-three percent of patients attended follow-up. No infections recurred. No significant differences were found in Knee injury and Osteoarthritis Outcome Scores for children, Lysholm scores, range-of-motion, leg length, gait and radiologic findings.

Conclusions: For acute pediatric septic knee arthritis, arthroscopic irrigation is associated with less repeat surgical irrigations and allows earlier knee ranging and weight-bearing compared with open irrigation. At long-term follow-up, no significant difference was found between groups.

Key Words: septic arthritis, knee, children

(*Pediatr Infect Dis J* 2018;37:413–418)

Septic arthritis in children is relatively uncommon in developed countries, with a stable incidence of 1–5 in 100,000.[1–3] The hip and knee are the most commonly involved joints.[4–8] Septic arthritis in children has been reported to cause chondrolysis, impaired ambulation, joint stiffness, deformity and osteonecrosis.[9–13] Repeated aspiration of the joint can be employed[14,15]; however, surgical joint irrigation is commonly used as it allows simultaneous debridement of loculations and joint visualization, unachievable by needle aspiration alone,[15,16] and has a lower failure rate.[17,18]

Whether this surgery should be arthroscopic or open has not been formally evaluated. Additionally, no study has analyzed variables to assess their effect on treatment efficacy for pediatric septic knee arthritis. Furthermore, literature lacks long-term clinical data comparing these treatment methods in children. Current studies are almost invariably arthroscopic or open case series.[12,18–21] This study's aim was to compare short-term and long-term outcomes after arthroscopic treatment versus open treatment for pediatric septic knee arthritis.

Accepted for publication September 4, 2017.

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The authors have no conflicts of interest or funding to disclose. Also, the authors have not received funding from National Institutes of Health (NIH); Wellcome Trust; Howard Hughes Medical Institute (HHMI); and other(s).

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ISSN: 0891-3668/18/3705-0413
DOI: 10.1097/INF.0000000000001795

MATERIALS AND METHODS

Study Design and Setting

Data from all pediatric patients with acute knee septic arthritis treated with arthroscopic or open methods from July 1996 to July 2016 at a level 1 tertiary referral institution was collated retrospectively. The patients were then reviewed in the orthopedic clinic by one of the authors (B.J.) for long-term sequelae. Patients were ascertained through diagnosis codes from our clinical information department. All children 12 years of age or less meeting Newman's septic arthritis criteria[22] with any etiology were included. Patients who had initial surgical irrigation in another hospital before being transferred to our institution were excluded. The institutions' ethics committee approved the study (approval number 16/04/20/5.04).

Diagnostic Criteria

Diagnosing septic arthritis was based on Newman's criteria[22] and graded accordingly as A, B or C (Table 1). This evidence was corroborated with children's clinical presentation, characteristically including knee pain, reluctance to weight-bear, joint warmth, effusion, erythema and painful and reduced range-of-motion (ROM). Preoperative white cell count (WCC) and C-reactive protein (CRP) were invariably elevated.

Treatment Type

Surgery was indicated based on clinical and laboratory evidence. The orthopedic surgeon decided whether to perform surgery by arthroscopic or open methods. No predetermined criteria were set for this decision. Arthroscopic irrigation was more commonly used earlier in this study period.

Surgical Method and Postoperative Care

Patients were supine and under general anesthesia. Sterile draping and skin preparation with povidone-iodine or chlorhexidine was performed. For arthroscopic irrigation, a standard anterolateral portal was made; an anteromedial portal was also utilized in some cases. A 4 mm or, in the smallest children, a 2.7 mm arthroscope was used. For open irrigation, a partial lateral or medial parapatellar arthrotomy was made. Infected material was sent for microscopy and culture. Joints were lavaged with 1 to 6 liters of normal saline. The incisions were closed, a drain was inserted when required and dressings applied. Postoperatively, patients were allowed to weight-bear as tolerated. Drains were removed approximately 48 hours postoperatively. Most commonly, intravenous flucloxacillin 50 mg/kg every 6 hours was given empirically,[23] then tailored to sensitivities in discussion with an infectious diseases specialist. Clinical deterioration including persistent joint irritability, fevers and a

TABLE 1. Classification of Septic Knee Infections by Newman Grade

Grade	Description	Arthroscopic (%)	Open (%)	All (%)	WCC*	*P* Value†
A	Organism isolated from joint	5 (45.5%)	9 (69.2%)	14 (58.3%)	98,800	0.408
B	Organism isolated from elsewhere	1 (9.1%)	1 (7.7%)	2 (8.3%)	25,600	>0.999
C	No organism isolated but (1) histologic or radiologic evidence of infection, or (2) turbid fluid aspirated from joint	5 (45.5%)	3 (23.1%)	8 (33.3%)	71,000	0.391

*Median white cell count from available knee arthrocentesis samples in our study cohort by Newman Grade.
†Fisher exact test used to calculate *P* values.

raised CRP provoked repeat surgical lavage within 4 days of the index procedure. In some cases, treatment was continued through our home intravenous antibiotic program.

Outcomes

The primary short-term outcome was initial surgical treatment success, determined by avoiding a second surgical irrigation. To assess function, time in days to range the knee (ability to flex and extend the knee well when the patient was examined postoperatively) and time to weight-bear postoperatively was recorded from the medical record. Additional short-term outcomes determined from patient records were mortality and length of stay (LOS).

At long-term follow-up, all patients were assessed by one clinician at our pediatric orthopedic clinic. Primary long-term outcomes were infection recurrence and reoperation assessed on patient history. Knee injury and Osteoarthritis Outcome Scores for children (KOOS-Child score) and Lysholm knee scores were collected. One patient in the arthroscopic group with cerebral palsy could not complete these scores. ROM of both knees was assessed with a goniometer while supine in the standard method.[24] Leg length difference (LLD) was measured by the direct method from anterior superior iliac spine to the medial malleolus.[25] Gait was assessed for abnormalities by direct observation during a 6-meter walk test. Standing anteroposterior and lateral radiographs of the knee were analyzed for infection sequelae including growth derangement or joint degeneration as described by Ilharreborde.[11]

Statistical Analysis

Categorical data was compared using Fisher exact test. The Wilcoxon rank-sum test was used for non-normal continuous data and student *t*-test was used for normally distributed data. All *P* values were 2 sided. Statistical significance was determined at $P < 0.05$. Twenty-two factors that potentially confounded the result were examined for an effect on the primary short-term outcome. Of these, only antibiotic type had a P value < 0.25. The primary analysis was stratified on this binary covariate and examined using the extended Mantel–Haenszel χ^2 test. This did not change the analysis' conclusion, so the original result was reported. Statistical analysis was completed using Stata software (StataCorp, TX).[26]

RESULTS

Patient Demographics, Clinical Presentation and Etiology

Over the 20 years, pediatric patients comprised approximately 13% of all patients with native knee septic knee arthritis treated at our institution. Twenty-eight pediatric patients had arthroscopic or open treatment for presumed acute knee septic arthritis. Three did not meet Newman criteria and were considered to have a reactive or sterile arthritis. Another had initial debridement at a different hospital and was also excluded. Consequently, 24 pediatric patients were treated exclusively at our institution. No patient had autoimmune arthropathy. Eleven (46%) received arthroscopic irrigation, while 13 (54%) underwent open irrigation. At long-term follow-up, one patient from the arthroscopic group and 3 from the open group were lost—1 moved interstate, 1 declined and 2 were uncontactable. Subsequently, 20 patients (83.3%) attended final follow-up comprising 10 patients from each group.

The median age in the arthroscopic group was 2.2 (range 0.6–9.9) years versus 1.5 (range 0.2–10.0) years in the open group. All cases were acute and monoarticular. One third of patients were febrile on presentation and 20% were tachycardic for their age.[27] Median symptom duration was 3 days (Table 2). The main etiology was hematogenous in both groups (72.7%; arthroscopic vs. 76.9%; open, $P > 0.999$). Other etiologies were also similar, with 2 superficial knee wounds ($P > 0.999$) and one penetrating injury in each group ($P > 0.999$).

TABLE 2. Patient Demographics, Clinical Presentation and Risk Factors

	Arthroscopic Group	Open Group	*P* value*	95% CI
No. of Patients	11	13	NA	NA
Female:male ratio (*n*)	6:5	6:7	>0.99	0.38–1.78
Median age and range (years)	2.2 (0.6–9.9)	1.49 (0.2–10.0)	0.35	−1.6 to 3.9
Right:left ratio (*n*)	4:7	7:6	0.44	0.58–3.8
Median symptom duration and Range (days)	3 (<1 to 13)	3 (<1 to 14)	0.93	−3.8 to 3.4
No. with fever ≥38°C (%)	5 (45.5%)	3 (23.1%)	0.39	0.16–1.7
No. of tachycardic (for age) patients (%)	2 (14.3%)	3 (23.1%)	>0.99	0.26–6.3
No. with pain/refusal to use lower limb (%)	10 (91.0%)	12 (92.3%)	>0.99	0.77–1.3
No. with knee swelling (%)	11 (100%)	11 (84.6%)	0.48	0.94–1.5
No. with knee warmth (%)	8 (72.7%)	9 (69.2%)	>0.99	0.63–1.8
Immunizations up to date (%)	11 (100%)	12 (92.3%)	>0.99	0.79–1.1
No. of premature patients (%)	2 (18.2%)	1 (7.7%)	0.58	0.044–4.1
No. with recent infection (%)	1 (9.1%)	1 (7.7%)	>0.99	0.060–12
No. with diabetes or immunosuppressed (%)	0 (0%)	0 (0%)	>0.99	NA

**P* values derived from Fischer exact test, excluding age and symptom duration which were evaluated using the Wilcoxon rank-sum test. All confidence intervals (CI) are quoted for the ratio of the clinical parameters between groups, excluding age and symptom duration which are the CI for the *difference* between groups.

Preoperative Laboratory and Radiology Findings

Preoperative WCC was elevated with neutrophilia in both groups. Median CRP was similarly raised in both groups (Table 3). Cell counts from joint fluid samples were unavailable from 3 patients in the arthroscopic group and 5 patients in the open group. From the samples available, median synovial fluid WCC was >50,000 × 10^6/L in both groups. Preoperative radiographs were taken for 9 patients in the arthroscopic group and 10 patients in the open group. No radiograph demonstrated osteomyelitis or physeal or epiphyseal abnormality. No meaningful difference existed between the groups regarding these preoperative factors.

Antibiotic Treatment

Flucloxacillin was the initial antibiotic in 18 patients (67%), which predicted a successful outcome (see below.) Four of these received another antibiotic simultaneously (2 ceftriaxone, 1 cefotaxime, 1 gentamicin.) Six patients initially received cephazolin alone, and 1 patient received vancomycin alone. Median intravenous antibiotic duration was 8.0 days in both groups (range 2–20 days, arthroscopic; range 3–56 days, open). Median oral antibiotic duration after this was 14.0 (range 0–28) days, arthroscopic versus 21.0 (range 0–42) days, open. Total median antibiotic duration was 29 days in both groups.

Microbiology

Overall, an organism was identified in two thirds of cases (Table 1). Of these, 87.5% of organisms were identified from joint samples (Newman Grade A) and 12.5% from blood cultures (Newman Grade B). In one third, no organism was identified despite a purulent effusion (Newman Grade C). The most common organisms were *Kingella kingae*, Methicillin-sensitive *Staphylococcus aureus* and *Streptococcus pyogenes* (Fig. 1). All culture-positive cases grew a single bacterial species.

Arthroscopy Versus Arthrotomy Success Rates

In the arthroscopic group 100% of patients were effectively treated with one procedure compared with 61.5% of patients in the open group, a difference of 38.5% [95% confidence interval (CI): 12%–65%, $P = 0.016$]. The median time to return to theatre was 3 (range 1–4) days. No patient in the open group required a third procedure. No deaths occurred in either group.

Time to Recover Knee Function and Length of Stay

Time to range the knee occurred earlier in the arthroscopic group (5.0 days, arthroscopic vs. 10.6 days, open, difference 5.5 days; 95% CI: 0.84–10.3, $P = 0.023$). Mean time to weight-bearing occurred earlier in the arthroscopic group (2.7, range 2–6 days, arthroscopic vs. 10.3, range 3–18 days, open, difference = 7.6 days; 95% CI: 2.3–12.9, $P = 0.008$) and preceded time to range the knee in both groups (Fig. 2). Weight-bearing data was unavailable from 4 patients in each group (typically the youngest patients). Inpatient LOS was 7.0 (range 5–21) days in the arthroscopic group compared with 11.0 (range 3–23) days in the open group ($P = 0.28$).

Late Infection Recurrence, Reoperation and Radiologic sequelae

No patient in either group had recurrence of infection at final follow-up ($P > 0.999$). One patient in each group had a further knee operation but neither was for infection ($P > 0.999$). One had an arthroscopy for an osteochondral injury, while another had a cyst excision. In both groups at final follow-up, no patient had radiologic evidence of arthritis, epiphyseal damage or physeal growth anomalies.

TABLE 3. Preoperative Laboratory Results

	Arthroscopic Group	Open Group	*P* Value
Blood*			
White blood cell count (×10^9/L)	13.3 (3.5)	15.1 (3.1)	0.84
Blood neutrophils (×10^9/L)	7.2 (1.7)	8.4 (2.6)	0.69
C-reactive protein (mg/L)	40.7 (24.9)	37.0 (49)	0.72
Knee arthrocentesis*			
White cell count (×10^6/L)	69,100 (50,400)	98,800 (16,400)	0.67
Polymorphonuclear cells %	90 (8)	90 (2.5)	0.69

*Results given as median values with SIQR (semi-interquartile range) in parentheses.

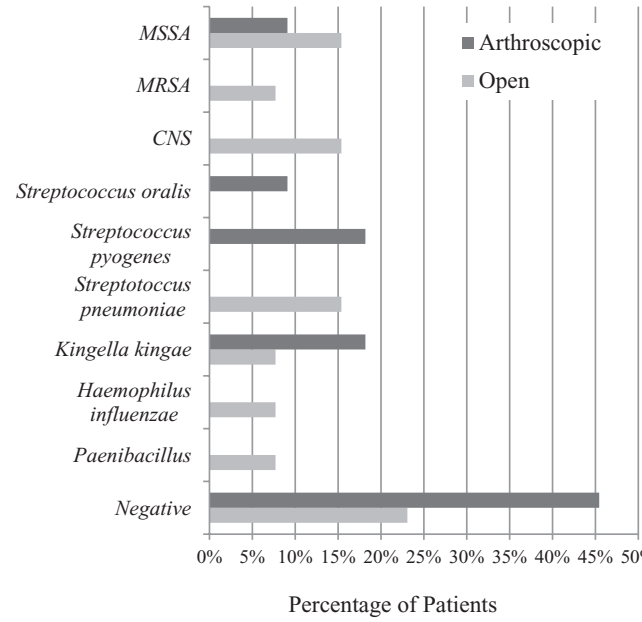

FIGURE 1. Microorganisms isolated from cultures taken from pediatric patients with septic arthritis of the knee. CNS, *Coagulase negative Staphylococcus*; MSSA, *Methicillin sensitive Staphylococcus aureus*; MRSA, *Methicillin resistant Staphylococcus aureus*. Note the predominance of *Staphylococcal* species, *Streptococcal* species and *Kingella kingae* in both groups.

KOOS-Child Score and Lysholm Knee Score

At final follow-up, mean KOOS-Child scores were noteworthy. No significant difference was found between groups. Pain scores were excellent in both groups (93.8 arthroscopic, range 57–100 vs. 97.0 open, range 86–100, $P = 0.85$). Symptom scores were similarly excellent (98.0 arthroscopic, range 93–100 vs. 97.0 open, range 86–100, $P = 0.96$). Activities of daily living scores were exceptional (96.7 arthroscopic, range 75–100 vs. 99.1 open, range 93–100, $P = 0.82$). Sport and recreation scores were 92.5 arthroscopic, range 64–100 vs. 94.3 open, range 75–100, $P > 0.99$. Quality of life scores were also high in both groups (90.1 arthroscopic, range 58–100 vs. 87.9 open, range 67–100, $P = 0.68$). Additionally, median Lysholm knee scores were comparable between groups (100, range 60–100; arthroscopic vs. 96.5, range 72–100; open, $P = 0.33$).

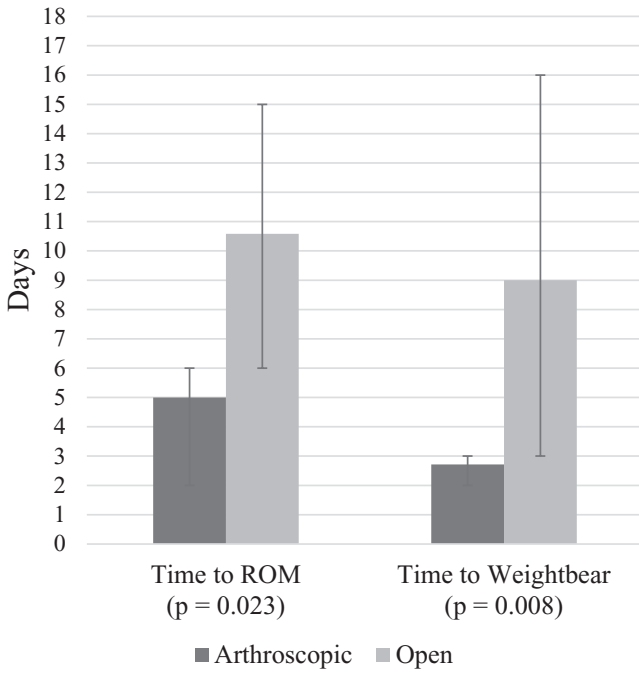

FIGURE 2. Postoperative knee function: arthroscopic versus open groups. Results given as means with 95% confidence intervals.

Knee Range of Motion, Leg Length Difference and Gait

Median knee ROM of the affected side was comparable between groups (Table 4). There was no LLD in any child greater than 5 mm (Table 4). After excluding the patient with cerebral palsy, gait was not abnormal in any patient.

Other Factors Associated With Treatment Success

The only other factor associated with a successful outcome was flucloxacillin use as the initial antibiotic ($P = 0.014$.) The benefit of an arthroscopic over an open procedure persisted after stratification for flucloxacillin use ($P = 0.039$).

DISCUSSION

For septic arthritis of the knee in pediatric patients, research has indicated the importance of surgical joint irrigation, particularly early initial irrigation rather than awaiting a patient to fail nonoperative management.[12,14,16] In children, percutaneous aspiration is another treatment option and typically effective if symptom duration is <5 days.[4,14,15,28,29] However, no studies directly comparing aspiration versus arthroscopy/arthrotomy for septic knees in children have been published. One study examined this for pediatric septic arthritis of the shoulder, showing no clinical difference after 1 year.[30] Only one study to the authors' knowledge has analyzed surgical irrigation by arthroscopy or arthrotomy for septic pediatric knees, having fewer cases than this current study, a scarcity of open cases (5 patients) and used a postoperative irrigation system.[16] Furthermore, minimal long-term data exist. Our study is the largest to compare children with acute septic knee arthritis treated by arthroscopic or open irrigation and has the longest average follow-up to date. We also examined other factors that affected initial treatment success and demonstrated that these did not influence the conclusion that arthroscopy is more successful than arthrotomy. After arthroscopic irrigation, patients are less likely to return to theatre, and they regain knee function earlier. At long-term follow-up, no significant difference was found between groups.

TABLE 4. Range of Motion and Leg Length at Long-term Follow-up

	Arthroscopic Group	Open Group	*P* Value
Range of motion (°)*			
Affected side	150.0° (2.9)	152.5° (2.8)	
Unaffected side	150.5° (2.3)	154.0° (2.8)	
Difference between limbs	0.0° (2.9)	−0.5° (1.9)	0.82
Leg length (cm)*			
Affected side	81.6 (8.4)	56.5 (11.9)	
Unaffected side	81.2 (8.3)	56.7 (11.9)	
Difference between limbs	0.1 (0.15)	−0.1 (0.14)	0.074

*Results given as median values with SIQR (semi-interquartile range) in parentheses.

Arthroscopy Versus Arthrotomy Success Rates

We found that 100% of patients with septic knee arthritis treated by arthroscopy were effectively cured after one procedure compared with only 61.5% in the open group. This difference was not accounted for by other observed factors in this study. This is the first report of this finding in the pediatric literature. In the adult literature, similar results have been found[31] and concurs with our previous findings.[32] Postulated reasons for the efficacy of arthroscopic irrigation include less iatrogenic local synovial tissue damage, which may harbor infection,[7] more thorough irrigation by joint distension and arthroscopic access, and possibly earlier joint nutrition through greater mobilization after less extensive incisions.

Time to Recover Knee Function

Time to weight-bear and time to range the knee both occurred significantly earlier in the arthroscopic group. We suggest this followed the combination of both smaller incisions and perhaps more effective irrigation. These reaffirm previous reports[16] and studies noting arthroscopic treatment allows prompt re-establishment of joint movement and weight-bearing.[12]

Length of Stay

Arthroscopy has been reported to reduce LOS previously for septic knee arthritis.[21] Early transition to oral antibiotics can also reduce LOS.[33] Median hospitalization was 3.5 days shorter in the arthroscopic group despite longer intravenous antibiotic use. Mean LOS after arthroscopic treatment was 9.4 days, similar to 9.8 days previously reported.[18]

Late Infection Recurrence and Reoperation

Late infection or relapse did not occur in either group. This supports previous case series finding infection recurrence typically occurs while an inpatient.[12,18,19,21] One reoperation occurred in each group, both unrelated to infection.[11]

KOOS-Child Score and Lysholm Knee Score

At a mean 6.9 years follow-up, KOOS-Child and Lysholm knee scores were excellent for both groups. No significant difference existed between groups across the 5 domains. Good functional results 5 years after surgical drainage of septic knees in children has been reported.[10] Postoperative KOOS-Child and Lysholm scores have been reported in one case series of arthroscopic irrigation of septic knees and also reported excellent results 5.4 years postoperatively.[18]

Knee Range of Motion, Leg Length Difference and Gait

Comparison of knee ROM, LLD or gait has not been reported in the pediatric literature after these surgical treatments. We found no poor results or significant differences between groups in these clinical parameters, concurring with one study, which found no leg length differences or deformity 3 years postoperatively.[12]

Radiologic Evidence of Sequelae

No patient demonstrated evidence of joint degeneration, epiphyseal damage or physeal growth anomalies agreeing with previous reports describing similar results at 3.1 years.[12] Early treatment in our study likely reduced occurrence of such sequelae.[13,17]

Flucloxacillin as the Initial Antibiotic

Empiric flucloxacillin treatment was also associated with avoiding a second irrigation. This should be cautiously interpreted as it was not part of the a priori research hypothesis, and multiple significance tests were performed post hoc. This result has not been previously reported and warrants further study. Nevertheless, national guidelines recommend flucloxacillin empirically for septic arthritis.[34] After stratification for flucloxacillin use, the benefit of an arthroscopic over an open procedure still persisted ($P = 0.039$).

Limitations

Our study was not randomized, raising the possibility that patients with more severe septic arthritis were selected for an open procedure. However, the fact that our cohorts were similar regarding clinical presentation, age, etiology, inflammatory markers, imaging findings and antibiotic treatment mitigates against selection bias being an important factor. Second, most data were collected retrospectively meaning that data on some of these factors were incomplete, for example, weight-bearing status data was not recorded for 4 patients in each group (typically the youngest). We doubt, however, that this would substantially change the study's conclusions as this would require the missing results to be substantially different from those available. Third, causative organisms vary between groups, for example, the arthroscopic group had a greater percentage of culture-negative cases, which may represent *Kingella kingae* infections, which can be milder.[35] Finally, follow-up time was longer for the arthroscopic group, and thus, long-term differences may be found with lengthier follow-up of the open group beyond the current average of 5.2 years.

CONCLUSION

In conclusion, for pediatric septic knee arthritis, initial arthroscopic irrigation was more successful than open irrigation in our study. This benefit was confined to early outcomes including significantly fewer repeat irrigation procedures, earlier time to weight-bearing and earlier time to range the knee. There was also a trend to shorter hospitalization. Long-term functional, clinical and radiologic outcomes were good in both groups and not significantly different. Given these findings, there is clinical equipoise for enrolment into a randomized control trial comparing arthroscopic to open treatment. Until this occurs, we advise consideration of arthroscopic treatment in conjunction with tailored antibiotics for the initial treatment of pediatric septic knee arthritis. In regions where arthroscopic equipment may not be readily available, open irrigation for pediatric septic knee arthritis does not result in inferior long-term outcomes compared with arthroscopic irrigation.

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