

# Arthrocentesis, arthroscopy or arthrotomy for septic knee arthritis in children: a systematic review

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## Abstract

**Purpose** Septic knee arthritis in children can be treated by arthrocentesis (articular needle aspiration) with or without irrigation, arthroscopy or arthrotomy followed by antibiotics. The objective of this systematic review was to identify the most effective drainage technique for septic arthritis of the knee in children.

**Methods** The electronic PubMed, Embase and Cochrane databases were systematically searched for original articles that reported outcomes of arthrocentesis, arthroscopy or arthrotomy for septic arthritis of the knee. The quality of all included studies was assessed with the Methodological Index for Non-Randomized Studies (MINORS) criteria. This systematic review was performed and reported according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines (PROSPERO).

**Results** Out of 2428 articles, 11 studies with a total of 279 knees were included in the systematic review. The quality of evidence was low (MINORS median 4 (2 to 7)). A meta-analysis could not be performed because of the diversity and low quality of the studies. In septic knee arthritis, additional drainage procedures were needed in 54 of 156 (35%) knees after arthrocentesis, in four of 96 (4%) after arthroscopy and in two of 12 (17%) after arthrotomy.

**Conclusion** Included studies on treatment strategies for septic arthritis of the knee in children are diverse and the scientific

quality is generally low. Knee arthroscopy might have a lower risk of additional drainage procedures as compared with arthrocentesis and arthrotomy, with acceptable clinical outcomes and no radiological sequelae.

*Level of evidence: IV*

Cite this article: Donders CM, Spaans AJ, Bessems JHJM, van Bergen CJA. Arthrocentesis, arthroscopy or arthrotomy for septic knee arthritis in children: a systematic review. *J Child Orthop* 2021;15:48-54. DOI: 10.1302/1863-2548.15.200129

**Keywords:** septic arthritis; knee; arthrocentesis; arthroscopy; arthrotomy

## Introduction

Acute septic arthritis in children is an orthopaedic emergency. The incidence of septic arthritis is two to seven per 100 000 children in Europe, and the most commonly affected joints are the hip and knee.<sup>1,2</sup> The classical presentation of septic arthritis in children is a combination of a painful joint with limited range of movement, fever, malaise and inability to bear weight on the involved limb.<sup>3-5</sup> A delay in diagnosis and inappropriate treatment can result in devastating damage to the joint with lifelong disability as a consequence.<sup>6</sup>

*Staphylococcus aureus* is the most commonly cultured organism. It is followed by *Kingella kingae*, *Streptococcus pyogenes* and *Streptococcus pneumoniae*, depending on the age of the child.<sup>7</sup> Antibiotic coverage should start in suspected cases as soon as blood cultures and synovial fluid samples are collected and the joint has been drained.<sup>4,5</sup>

Joint drainage techniques of the knee include arthrocentesis (articular needle aspiration), arthroscopy and arthrotomy. The technique of choice depends on the preference and experience of the treating clinicians and surgeons, according to the European Society for Paediatric Infectious Diseases (ESPID) Bone and Joint Infection Guidelines from 2017.<sup>1</sup> Arthrocentesis may be appropriate as the only invasive procedure in uncomplicated cases of *Staphylococcus aureus* in children, according to the ESPID. However, the literature is inconclusive with respect to the optimal drainage technique in children with septic arthritis. Therefore, this study aims to systematically review the literature concerning the optimal drainage technique for septic knee arthritis in children.

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## Methods

### *Study design*

This systematic review was performed and reported according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.<sup>8</sup> In accordance with these guidelines, the study was registered with the International Prospective Register of Systematic Reviews (PROSPERO) at <https://www.crd.york.ac.uk/PROSPERO/> under registration number CRD42018117795.

### *Literature search and study selection*

Three online medical databases (PubMed, Embase and the Cochrane database for clinical trials) were searched on 24 August 2019 using the following keywords: septic arthritis, child, arthrocentesis, arthroscopy, arthrotomy and their synonyms, each fitted for the specific databases. Full search details are available in the supplementary material. Studies were not blinded for author, affiliation or source. The results of the searches were cross-checked, and duplicate papers were excluded. The titles and abstracts of the remaining papers were screened by two independent reviewers (CMD and AJS) for suitability of inclusion. The reviewers read the full text to evaluate if the paper was eligible for inclusion. If an article was not accessible, then the authors were contacted. Additionally, the reference list of the included articles and review articles were manually checked for potentially missing articles. Any disagreement was resolved by discussion and consensus by the reviewers.

### *Inclusion and exclusion criteria*

The inclusion criteria for full text review were inclusion of at least five knee joints; age under 18 years; an established diagnosis of acute septic arthritis; and a surgical intervention (arthrocentesis, arthroscopy or arthrotomy). The diagnosis of acute septic arthritis was established when one or more of the following findings were found: pus aspirated from the joint; a positive culture of the joint fluid; a positive gram stain of the joint fluid and white blood cell count in the joint fluid > 50 000/mm<sup>3</sup>. All included articles presented original data on paediatric patients who had septic arthritis. Studies were limited to articles published in English, French, German or Dutch. Reviews, letters to the editor, case reports, expert opinions and surgical technique articles were excluded. If different joints or patients with (concomitant) osteomyelitis were included without separate analysis, then studies were also excluded from further analysis.

### *Data extraction*

The following parameters were recorded when available: numbers of joints, age, type of treatment (arthrocentesis, arthroscopy, arthrotomy), delay to treatment and

the duration of follow-up. Relevant outcome parameters included additional drainage arthrocentesis or surgical procedures, clinical outcomes and radiological sequelae.

### *Methodological quality*

To assess the risk of bias, we used the Methodological Index for Non-Randomized Studies (MINORS).<sup>9</sup> MINORS is a validated and established index for evaluating the methodological quality of non-randomized studies. Two reviewers (CMD and AJS) independently evaluated each study according to the MINORS index. The mean of these calculations was described.

### *Statistical analysis*

Descriptive data are presented in this review. Due to the heterogeneity of the data, especially the diversity of data from presentation to initiation of treatment, it was not possible to perform a meta-analysis and, therefore, no statistical tests were applied.

## Results

### *Selection process*

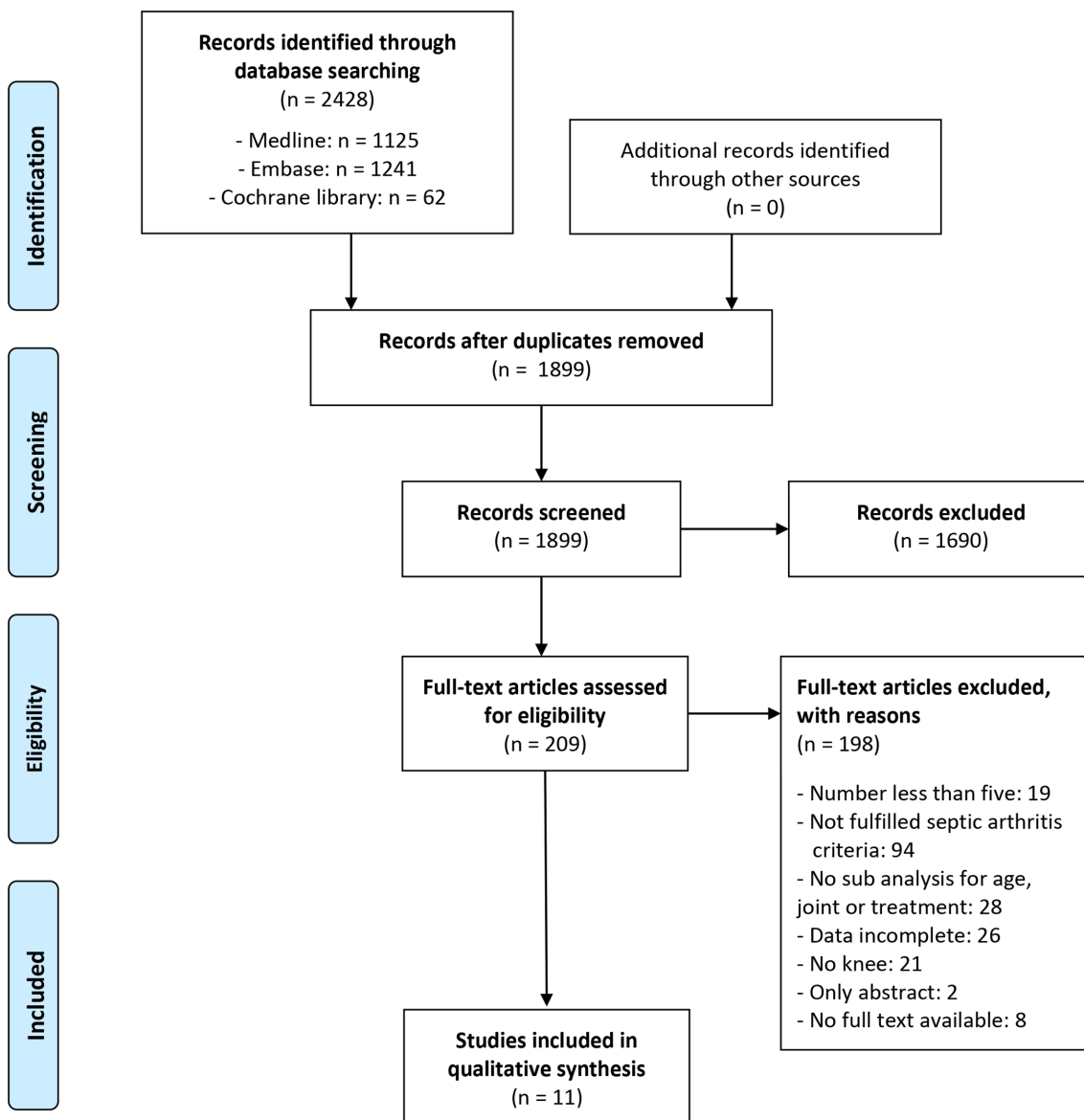
The search yielded a total of 2428 articles, including 1125 PubMed hits, 1241 Embase hits, and 62 Cochrane database hits. Duplicates were removed (n = 529) and 1899 articles were screened by title and abstract. A total of 209 studies were selected for full text screening, of which 177 articles were excluded. Another 21 studies were excluded because they did not include (enough) patients with septic arthritis of the knee. A total of 11 articles were included in this review. No additional relevant articles were found on the reference lists of the included articles and review articles. Figure 1 displays the study selection flowchart.

### *Methodological quality and risk of bias*

The individual MINORS score after consensus for all included articles is displayed in Tables 1 to 3. The median MINORS score of the included articles was 4 (2 to 7). The major limitations on the methodology of the selected studies were retrospective design and no unbiased assessment of endpoints.

### *Study characteristics*

All studies were retrospective.<sup>10-20</sup> The studies were conducted in the USA (n = 4), France (n = 2), Canada, Spain, Poland, Israel and Malaysia. A total of 279 knees with septic arthritis in children were included. The number of knees with septic arthritis widely varied across the studies, ranging from five to 65 joints. Three studies recruited 50 knees or more.<sup>15,16,20</sup> Wiley and Fraser<sup>10</sup> did mention the number of knees, but did not mention the number of patients.



**Fig. 1** PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) flow diagram of the study-selection process.

### Arthrocentesis

A total of 171 of 279 (64%) included knees were treated with arthrocentesis:<sup>10-13,15,16</sup> arthrocentesis without irrigation was performed in 139 of these 171 (81%) knees;<sup>11,12,15,16</sup> arthrocentesis combined with irrigation in 15 knees;<sup>10</sup> and arthrocentesis combined with irrigation followed by a passive drain with a mean drainage duration of five days (3 to 7) in 17 knees.<sup>13</sup>

### Additional drainage procedures

Additional drainage procedures were needed in 54 of 156 (35%) knees: 39 repetitive needle joint aspirations, two arthroscopies and 13 arthrotomies. Wiley and Fraser<sup>10</sup> did

not mention a number of patients with additional arthrocentesis, but mentioned that there were no additional arthrotomies. Tornero et al<sup>16</sup> showed that arthrocentesis did not require additional drainage in any patient younger than one year old.

### Clinical outcomes

A restriction in joint movement was seen in 15 of 101 (15%) knees and in three knees the pain remained.<sup>10-13,15</sup> In total, 13 of the 15 knees and the three knees in patients with pain were reviewed in Strong et al.<sup>15</sup> Halder et al<sup>12</sup> reported two patients with restricted knee joint movement. Both studies treated patients with septic arthritis by arthrocentesis without irrigation and did not mention the

**Table 1** Studies including septic arthritis of the paediatric knee joint treated by arthrocentesis

Study	Study design	Number of joints	Mean age (range)	Mean total delay (range)	Mean follow-up (range)	Treatment	Additional drainage procedure	Radiological outcome	Clinical outcome	MINORS
Wiley and Fraser 1979 <sup>10</sup>	Retrospective	15	0 to 16 yrs	nm	nm	(Repeated) arthrocentesis + irrigation	Multiple arthrocentesis (n = unk); no arthrotomy	All normal	All FROM, painless and no other complaints	3/16
Herndon et al 1986 <sup>11</sup>	Retrospective	15	2 yrs (0 to 13)	< 6 days	37 mths (12 to 68)	Arthrocentesis	Arthrotomy (n = 4)	All normal	All painless and no other complaints	4/16
Strong et al 1994 <sup>15</sup>	Retrospective	50	2 mths (0 to 2 yrs)	nm	74 mths (13 to 256)	Arthrocentesis	Multiple arthrocentesis (n = 32); arthrotomy (n = 3)	Definite change (n = 24)	Flexion contracture (n = 13); varus (n = 15); valgus (n = 9); limb discrepancy 1.8 cm (0 to 4.5) (n = 24); intermittent and mild pain (n = 3)	3/16
Halder et al 1996 <sup>12</sup>	Retrospective	9	0 yrs (9 to 18 days)	nm	3 to 16 mths (n = 4)	Arthrocentesis	Second arthrocentesis (n = 1); arthrotomy (n = 1)	nm	Normal joint function (n = 2); able to stand and normal growth (n = 1); restricted joint movement (n = 1)	4/16
Griffet et al 2011 <sup>13</sup>	Retrospective	17	5 yrs (0 to 12)	3 days (1 to 5)	23 mths (15 to 56)	Arthrocentesis + irrigation + drain 5 days (3 to 7)	Second arthrocentesis (n = 2)	All normal	All FROM, painless and no other complaints	5/16
Tornero et al 2019 <sup>16</sup>	Retrospective	65	2 yrs (0 to 14)	3 days (1 to 5)	> 12 mths	Arthrocentesis	Second arthrocentesis (n = 4); arthroscopy (n = 2); arthrotomy (n = 5)	nm	nm	7/16
Total		171	0-16y	1 to 5 days (74 knees nm)	3 to 256 mths (15 knees nm)	81.3% arthrocentesis; 8.8% with irrigation; 9.9% with irrigation and drain	65.4% none; 25.0% multiple arthrocentesis; 1.3% arthroscopy; 8.3% arthrotomy (15 knees nm)	75.3% normal; 24.7% changes (74 knees nm)	96.9% painless; 3.1% mild pain (74 knees nm)	4 (3 to 7)

nm, not mentioned; unk, unknown; FROM, full range of movement; MINORS, Methodological Index for Non-Randomized Studies

delay to treatment. The other 86 knees of patients in the other three studies were painless and the patients had no other complaints.<sup>10,11,13</sup>

### Radiological sequelae

Radiological sequelae at follow-up were seen in 24 of 97 (25%) knees.<sup>10,11,13,15</sup> All these sequelae were seen in the study of Strong et al.<sup>15</sup> They did not mention the delay to treatment and had a mean follow-up of six years. Examples of these radiological observations were windswept deformities with widened metaphysis and destruction of large parts of the epiphysis. The other three studies with 47 knees found no abnormalities on radiographic evaluation after septic knee arthritis.<sup>10,11,13</sup>

### Arthroscopy

A total of 96 of 279 (34%) knees with septic arthritis were treated with arthroscopy.<sup>17-20</sup> In 61 of these 96 (64%) knees a passive drain was placed after the arthroscopy.<sup>19,20</sup> Sanchez and Hennrikus<sup>19</sup> removed the drain after two days and Agout et al<sup>20</sup> had a mean drainage duration of five days (1 to 9).

### Additional drainage procedures

Additional drainage procedures were needed in four of 96 (4%) knees: in two cases a second arthroscopy was needed<sup>20</sup> and in two knees an arthrocentesis was performed two weeks after the arthroscopy because of a persistent large effusion.<sup>17</sup> None of these 96 knees needed an additional arthrotomy.

### Clinical outcomes

All 96 knees were painless and had no functional limitations.<sup>17-20</sup> Agout et al<sup>20</sup> reviewed the clinical outcomes in patients with 56 of these 96 knees using the Lysholm score and the knee injury and osteoarthritis outcome score for children (KOOS-Child score). They found a mean Lysholm score of 97 and a mean KOOS-Child score above 93.

### Radiological sequelae

In all of the 76 knees no radiological sequelae were seen.<sup>18-20</sup> All these knees had radiographic evaluation at follow-up with a range of six months to 12 years.

**Table 2** Studies including septic arthritis of the paediatric knee joint treated by arthroscopy

Study	Study design	Number of joints	Mean age (range)	Mean total delay (range)	Mean follow-up (range)	Treatment	Additional drainage procedure	Radiological outcome	Clinical outcome	MINORS
Smith 1986 <sup>17</sup>	Retrospective	20	6 yrs (0 to 12)	1 to 3 days	6 to 60 mths	Arthroscopy	Arthrocentesis after 2 wks (n = 2)	nm	All excellent result	2/16
Stanitski et al 1989 <sup>18</sup>	Retrospective	15	12 yrs (7 to 16)	2 to 4 days	37 mths (30 to 48)	Arthroscopy	None	All normal	All full active knee extension and flexion > 120°; no leg-length inequality or deformity; all painless and no other complaints	4/16
Sanchez and Hennrikus 1997 <sup>19</sup>	Retrospective	5	1 yr (0 to 2)	2 days (1 to 3)	26 mths (6 to 38)	Arthroscopy + drain 2 days	None	All normal	All FROM; no length discrepancy; no functional limitations	4/16
Agout et al 2015 <sup>20</sup>	Retrospective	56	3 yrs (0 to 11)	3 days (0 to 16)	65 mths (26 to 141)	Arthroscopy + drain 5 days (1 to 9)	Second arthroscopy (n = 2)	All normal	Extension 0.3° (0° to 10°); flexion 148.8° (120° to 160°); < 5 mm limb-length discrepancy (n = 3); mean Lysholm score 96.9; mean KOOS-Child scores 95 for symptoms, 97 for pain, 98 for daily life, 93 for sport and 95 for quality of life; no pain; all patients resumed sport at their previous level	6/16
Total		96	6 yrs (0 to 16)	3 days (0 to 16)	6 to 141 mths	36.5% arthroscopy; 63.5% arthroscopy with drain	95.8% none; 2.1% arthrocentesis; 2.1% arthroscopy	100% normal (20 knees nm)	100% painless	4 (2 to 6)

nm = not mentioned; FROM, full range of movement; KOOS-Child scores, the knee injury and osteoarthritis outcome score for children; MINORS, Methodological Index for Non-Randomized Studies

**Table 3** Studies including septic arthritis of the paediatric knee joint treated by arthrotomy

Study	Study design	Number of joints	Mean age (range)	Mean total delay (range)	Mean follow-up (range)	Treatment	Additional drainage procedure	Radiological outcome	Clinical outcome	MINORS
Wiley and Fraser 1979 <sup>10</sup>	Retrospective	7	0 to 16 yrs	nm	nm	Arthrotomy	Arthrotomy (2e (n = 1), 3e (n = 1))	Destruction of the entire articular surface of the medial femoral condyle (n = 1)	Growth disturbance with permanent disability (n=1)	3/16
Katz et al 1990 <sup>14</sup>	Retrospective	5	3 yrs (0 to 9)	4 days (3 to 6)	24 mths (12 to 48)	Arthrotomy + drain	None	Partial destruction of the medial tibial plateau (n = 1)	All FROM, painless and no other complaints	2/16
Total		12	0 to 16 yrs	-	-	58.3% arthrotomy; 41.7% arthrotomy with drain	83.3% none; 16.7% arthrotomy	83.3% normal; 16.7% changes	-	3 (2 to 3)

nm, not mentioned; FROM, full range of movement; MINORS, Methodological Index for Non-Randomized Studies

### Arthrotomy

Two studies reviewed a total of 12 knees with septic arthritis treated with arthrotomy.<sup>10,14</sup> Five of these joints were treated with an arthrotomy of the knee with additional suction drainage.<sup>14</sup>

### Additional drainage procedures

In two of 12 (17%) knees an additional drainage procedure was needed after arthrotomy. In the study of Wiley

and Fraser<sup>10</sup> one of the seven knees needed a second arthrotomy and one other knee underwent two additional arthrotomies. In the study of Katz et al<sup>14</sup> none of the knees needed a second surgery.

### Clinical outcomes

Growth disturbance with permanent disability was observed in one knee, which had three arthrotomies.<sup>10</sup> The other 11 knees had full range of movement and no pain.<sup>10,14</sup>

### Radiological sequelae

In two of 12 (17%) knees radiological sequelae were seen. One knee had a partial destruction of the medial tibial plateau.<sup>14</sup> The other knee, which needed three arthrotomies, had destruction of the entire articular surface of the medial femoral condyle.<sup>10</sup>

## Discussion

This systematic review is a comprehensive review of the literature on drainage techniques for septic knee arthritis in children. It was found that arthroscopy may have a lower risk of an additional drainage procedure as compared with arthrocentesis and arthrotomy. However, the included studies are diverse and the scientific quality is generally low. Therefore, it is inappropriate to draw firm conclusions from the collected results.

To the best of our knowledge, this is the first detailed systematic review about surgical treatment of septic knee arthritis in children. In 2009, Kang et al<sup>21</sup> published a systematic review of the English language literature about the management of septic arthritis in children but unfortunately did not provide an overview of the results of the included studies. They concluded that the roles of arthrocentesis, arthroscopy and arthrotomy are unclear.

Each of the different drainage techniques have advantages and disadvantages. Arthrocentesis has the advantage of being a minimally invasive and short procedure. It may be technically easier than arthroscopy or arthrotomy in the very young child with use of ultrasound guidance and if necessary with an anaesthetic. However, repetitive arthrocentesis in a young child without anaesthesia or sedation can be an anxiety producing and painful experience. Advantages of arthroscopy include direct visualization of the joint, the ability to perform a complete debridement of the necrotic synovium and a thorough irrigation of the joint with minimal operative morbidity.<sup>19,22</sup> An arthrotomy gives a good overview of the joint and allows for ample irrigation, but a disadvantage is a larger incision with more scar tissue. It is, therefore, important to know how often additional arthrocentesis, arthroscopies and arthrotomies will take place to control the infection.

The age of the child may also influence the surgeon's decision on the preferred drainage technique. Tornero et al<sup>16</sup> showed that arthrocentesis did not require additional drainage in any patient with septic knee arthritis younger than one year. Strong et al<sup>15</sup> treated patients with a mean age of two months and Halder et al<sup>12</sup> treated patients between nine and 18 days of age. In contrast to Tornero et al,<sup>16</sup> they required additional arthrocentesis and arthrotomies in some children treated primarily with arthrocentesis. However, they did not mention the delay to treatment, which may influence the outcomes.

Fewer additional drainage procedures were found after arthroscopy in patients with an age of less than two years compared with arthrocentesis.<sup>19,20</sup> However, arthroscopy is technically demanding in a very small joint. Moreover, different diameter scopes were used in the studies so comparison should be interpreted with caution.<sup>19,20</sup> Thus, arthrocentesis might be advantageous in the very young, while arthroscopy seems beneficial at all ages when technically feasible.

One of the strengths of this review is the comprehensive systematic search method to identify all relevant articles on this subject. An established diagnosis of acute septic arthritis was defined in our inclusion criteria. We have used the numbers and results of all patients of the available articles to show a detailed overview of the available literature of the results of the different treatments of septic knee arthritis in children.

There are also several limitations. Unfortunately, all studies are retrospective. Even low-quality articles provide interesting data and have been included in this study in order to present a complete literature overview. Seven of the 11 studies had a minimum follow-up of one year and two had a mean follow-up of five years, which may influence the outcomes. Most included articles were incomplete in reporting important details, e.g. the delay to treatment was not always mentioned. The unknown delay in the study of Strong et al<sup>15</sup> might result in a remarkably higher percentage of deformity and radiological sequelae. Because of the small numbers of included patients, pooling of the data or sub-analyses on the basis of age were not possible.

In conclusion, this systematic review shows a clear overview of the literature on drainage techniques for septic knee arthritis in children. Included studies are diverse and the scientific quality is generally low. Knee arthroscopy might have a lower risk of additional drainage procedures as compared with arthrocentesis and arthrotomy. In the very young child, arthrocentesis of the knee may be beneficial because of its minimally invasive nature. The results of the present review may assist the paediatric orthopaedic surgeons treating children with acute septic arthritis of the knee. A prospective, multi-centre study with larger numbers of patients, an established diagnosis of acute septic arthritis and an adequate follow-up time is recommended.

Received 31 May 2020; accepted after revision 24 November 2020.

## COMPLIANCE WITH ETHICAL STANDARDS

### FUNDING STATEMENT

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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#### ETHICAL STATEMENT

**Ethical approval:** This article does not contain any studies with human participants or animals performed by any of the authors.

**Informed consent:** This systematic review consists solely of previously published studies and all studies are correctly referred to. Informed consent was not required for this work.

#### ICMJE CONFLICT OF INTEREST STATEMENT

None declared.

#### AUTHOR CONTRIBUTIONS

CMD: Data curation, Methodology, Study selection, Data extraction, Data analysis, Writing of the manuscript – review and editing.

AJS: Data curation, Methodology, Study selection, Data analysis, Critical revision of the manuscript – review and editing.

JHJB: Methodology, Data extraction, Data analysis, Critical revision of the manuscript – review and editing.

CIABV: Conceptualization, Methodology, Data analysis, Supervision, Writing of the manuscript – review and editing.

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