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# Comparison of Various Joint Decompression Techniques in Septic Arthritis of the Hip in Children: A Systematic Review and Meta-Analysis

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The aim of this review is to conduct an analysis of existing literature on outcomes of application of various methods of joint decompression in management of septic arthritis of the hip in children. A search of literature in PubMed, Embase, and Google Scholar was conducted for identification of studies reporting on the outcomes of intervention for septic arthritis of the hip in children. Of the 17 articles selected, four were comparative studies; two of these were randomized controlled trials while the rest were single arm studies. Statistical difference was observed between the proportion of excellent clinical and radiological outcomes in arthrotomy (90%, 95% confidence interval [CI] 81-98%; 89%, 95% CI 80-98%), arthroscopy (95%, 95% CI 91-100%; 95%, 95% CI 90-99%), and arthrocentesis (98%, 95% CI 97-100%; 99%, 95% CI 97-100%), respectively. The highest overall rate of additional unplanned procedures was observed in the arthrocentesis group (24/207, 11.6%). Patients who underwent arthrocentesis had a statistically greater chance of excellent clinical and radiological outcomes, although the highest level of need for additional unplanned surgical intervention was observed in the arthrocentesis group, followed by the arthroscopy group and the arthrotomy group. Future conduct of a prospective multicentric study focusing on the developed and developing world, along with acquisition of data. such as delay of treatment and severity of disease will enable assessment of the efficacy of one technique over the other by surgeons worldwide.

**Key Words**: Child septic hip arthritis, Arthrocentesis, Arthroscopy, Arthrotomy

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## INTRODUCTION

Involvement of the hip joint is common in septic arthritis in children[1]. A prompt diagnosis is required in management of patients with septic arthritis of the hip joint, and failure could lead to lifelong morbidity. This condition could result in destruction of the upper femoral physis, leg length discrepancy, pathological fractures, and instability of the hip joint[2]. *Staphylococcus aureus* remains the most common causative organism. In such cases the mainstay of treatment includes early antibiotic therapy along with decompression of the joint[3].

Techniques for joint decompression include arthrotomy, arthroscopy, and joint aspiration (arthrocentesis). Although arthrotomy has been regarded as a classic age-old technique for joint decompression/new techniques such as arthroscopic drainage and arthrocentesis are more commonly preferred in the effort to reduce morbidity associated with arthrotomy[4]. No consensus has been reached with regard to the optimal method of joint decompression. The aim of this review is to conduct an analysis of the existing literature regarding the outcomes of application of various methods of joint decompression in management of septic arthritis of the hip in children.

## MATERIALS AND METHODS

### 1. Literature Search

This systematic review was conducted and reported according to guidelines for Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). A search of literature in PubMed, Embase, and Google Scholar was conducted on 24 January 2022 using the following keywords: “Child septic hip arthritis”, “Child infectious hip arthritis”, “Child bacterial hip arthritis”, “Arthrocentesis”, “Arthroscopy”, “Arthrotomy”, and “Joint aspiration”. The following string was used for the search?-“([Child septic hip arthritis] OR [Child Infectious hip arthritis] OR [Child bacterial hip arthritis] AND [Arthrotomy] OR [Arthroscopy] OR [Arthrocentesis] OR [Joint Aspiration])”. The goal of the search was to identify studies reporting the outcomes of intervention in septic arthritis of the hip in children. “Humans” and age criteria were the filters selected in order to streamline the search results. Suitable modifications were made for each database. Duplicates were excluded after cross-checking the articles using the de-duplication function on Zotero. Initial screening of the titles and abstracts was performed by two authors (S.B., S.G.P.) followed by full-text analysis of the articles to determine the suitability for inclusion. This was augmented by manual checking of the bibliography of the included articles for identification of missing articles. Any disagreement was resolved by the intervention of the senior author (V.R.).

### 2. Study Selection

The inclusion criteria for this study included (1) articles on septic arthritis of the hip in children, (2) intervention in the form of arthrotomy, arthroscopy, or arthrocentesis, and (3) reporting of objective outcomes. No criteria were established in terms of the follow-up period. Review articles, systematic reviews, meta-analyses, conference presentations, case reports (less than 5 hips), letters to editor, and studies in languages other than English and German as well as studies that did not meet the inclusion criteria described above were excluded. Only studies that reported on septic hips during the acute period were included. Studies focusing on a single microorganism, septic hip dislocation, measurement of intracapsular pressure, and sequalae of septic arthritis of the hip in children were also excluded. Studies that also analyzed septic arthritis of other joints were excluded in cases where separate data regarding outcomes in the hip joint was not provided.

### 3. Data Extraction

Extraction of pre-defined data was performed by two authors (S.B., S.G.P.). Extraction of data was performed using three separate Excel sheets–one for each intervention (arthrotomy, arthroscopy, and arthrocentesis). Data were extracted from the included studies as follows: number, sex, age at affection, follow-up period, and objective outcome (clinical and radiological). In the absence of an objective score, a clinical outcome with no functional limitations was considered excellent and radiological outcome was considered excellent if no abnormality was observed on the last follow-up radiograph. The following data were collected wherever available: duration of hospital stay, duration of antibiotics, number of aspirations, and amount of aspirate.

### 4. Quality Appraisal

A quality appraisal of the studies was performed using the Newcastle Ottawa scale (NOS) and the Methodological

Index for Non-Randomized Studies (MINORS) score[5,6]. NOS employs a star system, so that judgement of studies is based on three broad criteria: selection of the study groups, their comparability, and the ability to determine the outcome of interest in these studies. MINORS score has a 12-point marking, with the first eight for non-comparative studies. This system was developed by a group of surgeons as a result of a lack of randomized studies in any surgical field. The MINORS score is a summation of individual item scores (zero to two for each item), with a maximum of 24 for comparative studies and 16 for noncomparative studies.

## 5. Statistical Analysis

According to postulation, demographic data, follow-up period, and method of hip decompression in management of septic arthritis in children would account for heterogeneity. $I^2$ statistic, a tool for use in describing the proportion of total variation in study estimates considered due to heterogeneity, quantifies the inter-study variability. Low, moderate, and high heterogeneity was ascribed to $I^2$ values of 25%, 50%, and 75% respectively. Sensitivity analysis was performed for assessment of articles contributing to heterogeneity. Analysis of descriptive data including mean, standard deviation, and range was performed using the metafor package included in R statistical software v4.0.0 (R Development Core Team, 2020). Analysis was

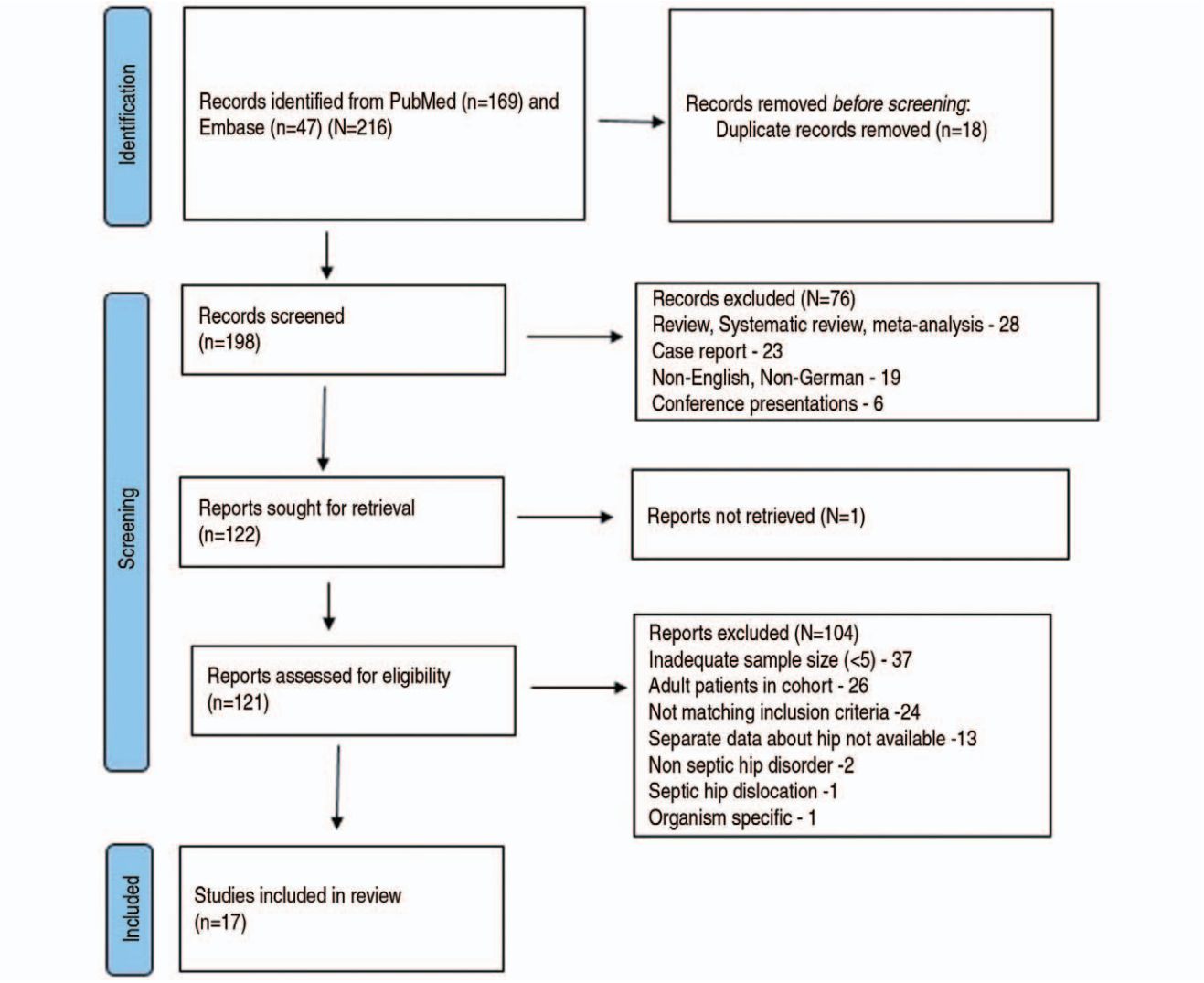


**Fig. 1.** Details of the study protocol according to PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines.

performed using a random-effects model according to the DerSemonian Laird method. Subgroup analysis was performed based on the method of joint decompression used (arthrotomy vs. arthroscopy vs. arthrocentesis). A proportional meta-analysis was performed for analysis of the number of hips showing excellent to good outcome based on the objective criteria used in the study. A funnel plot was constructed for assessment of publication bias. A *P*-value of less than 0.05 was considered significant.

## RESULTS

### 1. Literature Search

The initial search yielded 216 articles; of these, 18 articles were duplicates and were subsequently removed (Fig. 1). After screening of the title and abstracts, 121 articles were determined as suitable for further full text reading. A total of 104 articles were excluded; inadequate sample size (n=37) and adult patients in the cohort (n=26) were the most commonly noted reasons. Finally, 17 articles were selected for inclusion in the current systematic review and proportional meta-analysis.

### 2. Study Details

Of the 17 articles selected, four articles were comparative studies; of these, two were randomised controlled trials while the rest were single arm studies[7-10]. The mean MINORS and NOS score was 9.7 and 4, respectively, indicating inherent systematic deficiencies in the studies included (Table 1, 2). All but one study reported clinical and radiological outcomes on an objective basis[11]. The Bennett classification and Harris hip score were the objective scores used most often for assessment of the outcomes. Although neither of the above-mentioned validated criteria were used in eight studies, they nevertheless provided an objective assessment of the outcome[8,9,12-17]. Seven studies reported on outcomes of arthroscopy and arthrocentesis while five studies focused on arthrotomy outcomes. Only one study did not provide details regarding the duration of antibiotic treatment or hospital stay[12]. Four studies included details regarding the amount of aspirate on aspiration in each patient[8,11,13,14]. Six studies reported details regarding additional surgical intervention apart from the primary focus of the study[8,10,12,13,15,16]. Low heterogeneity was observed for studies reporting on arthroscopy and arthrocentesis while moderate heterogeneity ($I^2$=65%) was observed for studies on arthrotomy. The results of sensitivity analysis showed that one study contributed highly to this heterogeneity[7].

### 3. Demographic Data

The pooled data included information on 401 hips; arthrocentesis accounted for the maximum (207/401, 51.6%), followed by arthrotomy (108/401, 26.9%) and arthroscopy (86/401, 21.4%) with a slight predominance of males (221/401, 55.1%). The mean age of the subjects was similar across all groups–arthrotomy, 5.1 years (range, 8 days to 13 years); arthroscopy, 6 years (range, 3 months to 13 years); arthrocentesis, 5.4 years (range, 6 months to 15 years) (Table 3). The mean follow-up period was significantly longer in the arthrocentesis group (4.7 years [range, 1 month to 12 years]) compared to the arthrotomy (2.5 years [range, 14 months to 11 years]) and arthroscopy groups (2.9 years [range, 4 months to 7 years]). The longest follow-up period in each category was 12 years in the study by Givon et al.[13] (arthrocentesis), seven years in the study by Nusem and McAlister[18] (arthroscopy), and 11 years in the study by Chen et al.[19] (arthrotomy). The duration of hospital stays and antibiotic coverage was heterogeneous across all studies.

### 4. Clinical and Radiological Outcomes

Bennett classification and Harris hip score were used for assessing the outcome in eight studies, while the remaining studies performed objective assessment based on clinical features and radiological outcome at the last follow-up. Statistical difference was observed between the proportion of excellent clinical outcomes in arthrotomy (90%, 95% CI 81-98%) and arthrocentesis (98%, 95% CI 97-100%) (Fig. 2). An intermediate proportion of excellent clinical outcomes was observed for arthroscopy (95%, 95% CI 91-100%). Similar results were obtained from comparison of the proportion of excellent radiological outcomes and a statistical difference was observed between arthrotomy (89%, 95% CI 80-98%) and arthrocentesis (99%, 95% CI 97-100%) with an intermediate proportion of excellent radiological outcomes in arthroscopy (95%, 95% CI 90-99%) (Fig. 3).

### 5. Complications

Seven studies reported on both clinical and radiological findings, which indicated suboptimal outcomes in the hips[7,10,14,15,19-21]. The most common complication associated

**Table 1.** Risk of Bias Assessment Using MINORS (Methodological Index for Non-Randomized Studies) Tool

| No. | Study | Type of study | A clearly stated aim | Inclusion of consecutive patients | Prospective collection of data | End points appropriate to aim of study | Unbiased assessment of end points | Follow-up period appropriate to aim of study | Loss of follow-up <5% | Prospective calculation of study size | An adequate control group | Contem-porary groups | Baseline evaluation of groups | Adequate statistical analysis | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Chung et al.[9] (1993) | Prospective case series | 1 | 2 | 0 | 1 | 0 | 1 | 0 | 0 | NA | NA | NA | NA | 5/16 |
| 2 | Chen et al.[19] (2001) | Retrospective case series | 2 | 2 | 2 | 2 | 0 | 2 | 2 | 0 | NA | NA | NA | NA | 12/16 |
| 3 | Umer et al.[20] (2003) | Retrospective case series | 2 | 2 | 2 | 2 | 0 | 2 | 2 | 0 | NA | NA | NA | NA | 12/16 |
| 4 | Givon et al.[13] (2004) | Retrospective case series | 2 | 1 | 2 | 2 | 0 | 2 | 0 | 0 | NA | NA | NA | NA | 9/16 |
| 5 | El-Sayed[7] (2008) | RCT | 2 | 2 | 2 | 2 | 0 | 2 | 2 | 0 | 2 | 2 | 2 | 2 | 20/24 |
| 6 | Belthur et al.[17] (2009) | Retrospective Comparative study | 2 | 2 | 2 | 2 | 0 | 2 | 0 | 0 | NA | NA | NA | NA | 10/24 |
| 7 | Pääkkö-nen et al.[8] (2010) | RCT | 2 | 2 | 2 | 2 | 0 | 2 | 0 | 0 | 0 | 2 | 2 | 0 | 14/24 |
| 8 | Griffet et al.[14] (2011) | Retrospective case series | 2 | 2 | 2 | 2 | 0 | 2 | 2 | 0 | NA | NA | NA | NA | 12/16 |
| 9 | Jour-neau et al.[15] (2011) | Retrospective comparative study | 2 | 2 | 2 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 0 | 12/24 |
| 10 | Nusem and Mc-Alister[18] (2012) | Retrospective case series | 2 | 2 | 2 | 2 | 0 | 2 | 2 | 0 | NA | NA | NA | NA | 12/16 |

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**Table 1.** Continued

| No. | Study | Type of study | A clearly stated aim | Inclusion of consecutive patients | Prospective collection of data | End points appropriate to aim of study | Unbiased assessment of end points | Follow-up period appropriate to aim of study | Loss of follow-up <5% | Prospective calculation of study size | An adequate control group | Contem-porary groups | Baseline evaluation of groups | Adequate statistical analysis | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 | Fernan-dez et al.[10] (2013) | Prospective case series | 2 | 2 | 2 | 1 | 0 | 2 | 2 | 0 | NA | NA | NA | NA | 11/16 |
| 12 | San-pera et al.[21] (2015) | Retrospective case series | 2 | 2 | 2 | 2 | 0 | 2 | 2 | 0 | NA | NA | NA | NA | 12/16 |
| 13 | Kotlar-sky et al.[11] (2016) | Retrospective case series | 2 | 2 | 2 | 2 | 0 | 2 | 2 | 0 | NA | NA | NA | NA | 12/16 |
| 14 | Weigl et al.[16] (2016) | Retrospective cohort study | 2 | 2 | 2 | 2 | 0 | 2 | 1 | 0 | 0 | 2 | 2 | 2 | 17/24 |
| 15 | Duman et al.[26] (2019) | Retrospective case series | 2 | 2 | 2 | 2 | 0 | 2 | 2 | 0 | NA | NA | NA | NA | 12/16 |
| 16 | Garg et al.[12] (2020) | Retrospective case series | 2 | 2 | 2 | 1 | 0 | 2 | 1 | 0 | NA | NA | NA | NA | 10/16 |
| 17 | Essa et al.[29] (2022) | Retrospective case series | 2 | 2 | 2 | 2 | 0 | 2 | 2 | 0 | NA | NA | NA | NA | 12/16 |

**Table 2.** Newcastle Ottawa Scale

| No. | Study | Selection | | | | Comparability | | Exposure | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Is case definition adequate | Representativeness of the cases | Selection of controls | Definition of controls | For age and education | Other factors | Ascertainment of exposure | Same ascertainment methods used for case and control | Non response rate same for case and control | Non response rate different for case and control |
| 1 | Chung et al.[9] (1993) | * | * | | | | | * | | | |
| 2 | Chen et al.[19] (2001) | * | * | | | | | * | | | |
| 3 | Umer et al.[20] (2003) | * | * | | | | | * | | | |
| 4 | Givon et al.[13] (2004) | * | * | | | | | * | | | |
| 5 | El-Sayed[7] (2008) | * | * | * | * | * | * | * | * | | |
| 6 | Belthur et al.[17] (2009) | * | * | | | | | * | | | |
| 7 | Pääkkö-nen et al.[8] (2010) | * | * | * | * | | * | * | * | * | |
| 8 | Griffet et al.[14] (2011) | * | * | | | | | * | | | |
| 9 | Journeau et al.[15] (2011) | * | * | | * | * | | * | * | | |
| 10 | Nusem and McAlister[18] (2012) | * | * | | | | | * | | | |

(Continued to the next page)

**Table 2.** Continued

| No. | Study | Selection | | | | Comparability | | Exposure | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Is case definition adequate | Representativeness of the cases | Selection of controls | Definition of controls | For age and education | Other factors | Ascertainment of exposure | Same ascertainment methods used for case and control | Non response rate same for case and control | Non response rate different for case and control |
| 11 | Fernandez et al.[10] (2013) | * | * | | | | | * | | | |
| 12 | Sanpera et al.[21] (2015) | * | * | | | | | * | | | |
| 13 | Kotlarsky et al.[11] (2016) | * | * | | | | | * | | | |
| 14 | Weigl et al.[16] (2016) | * | * | | * | | * | * | * | | * |
| 15 | Duman et al.[26] (2019) | * | * | | | | | * | | | |
| 16 | Garg et al.[12] (2020) | * | * | | | | | * | | | |
| 17 | Essa et al.[29] (2022) | * | * | | | | | * | | | |

**Table 3.** Demographic Data of the Studies Included in the Review

| No. | Study | Subgroup | No. of patients | Sex | Age | Follow-up | Duration of antibiotics | Duration of hospital stay |
|---|---|---|---|---|---|---|---|---|
| 1 | Chung et al.[9] (1993) | Arthroscopy | 9 | Male: 5 | 4.4±1.06 yr (2.4-7.3) | Up to 8 mo | Intravenous: 7-14 days Total: 3-6 wk | |
| 2 | Chen et al.[19] (2001) | Arthrotomy | 33 | Male: 23 | 5 yr (8 days to 13 yr) | 6 yr (2-11) | Intravenous: 2 wk Oral: 2 wk | |
| 3 | Umer et al.[20] (2003) | Arthrotomy | 39 | Male: 23 | 3.9 yr (9 days to 13 yr) | 76 wk (45-105) | Intravenous: 3 wk Oral: 3 wk | 21 days (15-39) |
| 4 | Givon et al.[13] (2004) | Arthrocentesis | 34 | Male: 17 | 4.2 yr (0.5-15) | 6.1 yr (2-12) | | Without additional surgery: 10.6 days With surgery: 16.1 days |
| 5 | El-Sayed[7] (2008) | Arthrotomy | 10 | Male: 6 | 7.3 yr (3-12) | 23 mo (14-39) | 43.3 days (35-52) | 6.4 days (4-9) |
| | | Arthroscopy | 10 | Male: 5 | 8 yr (4-12) | 21.7 mo (13-30) | 45.6 days (37-53) | 3.8 days (3-6) |
| 6 | Belthur et al.[17] (2009) | Arthrotomy | 14 | Male: 9 | 7 yr (7 mo to 12 yr) | 32.5 mo (20-65) | 9.11 wk (4-24) | 6.78 days (3-13) |
| 7 | Pääkkönen et al.[8] (2010) | Arthrotomy | 12 | Male: 4 | 5.5 yr (IQR 2.8-8.8) | Minimum 1 yr | 29.7 days | 18 days |
| | | Arthrocentesis | 50 | Male: 28 | 7.7 yr (IQR 4.7-11.5) | Minimum 1 yr | 25.4 days | 12.9 days |
| 8 | Griffet et al.[14] (2011) | Arthrocentesis | 19 | Male: 9 | 4.85±2.71 yr | 6.16±2.09 mo | | |
| 9 | Journeau et al.[15] (2011) | Arthrocentesis | 40 | Male: 29 | 5.25 yr (3 days to 14 yr) | 16 mo (1-78) | Intravenous: 11.4 days (4-32) Oral: 6.8 wk (2-24) | |
| 10 | Nusem and McAlister[18] (2012) | Arthroscopy | 6 | Male: 3 | 9.5 yr (6-13) | 51.8 mo (14-84) | Intravenous: 2-3 wk Oral: 3 wk | 4 days |
| 11 | Fernandez et al.[10] (2013) | Arthroscopy | 20 | Male: 11 | 6.4 yr (2-14) | 2.9 yr (0.5-4.5) | Intravenous: 2 wk Oral: 4 wk | |
| 12 | Sanpera et al.[21] (2015) | Arthroscopy | 12 | | 6 yr (19 mo to 12 yr) | | 4-6 wk | |

(Continued to the next page)

**Table 3.** Continued

| No. | Study | Subgroup | No. of patients | Sex | Age | Follow-up | Duration of antibiotics | Duration of hospital stay |
|---|---|---|---|---|---|---|---|---|
| 13 | Kotlarsky et al.[11] (2016) | Arthrocentesis | 14 | Male: 7 | 2.5 yr (0.5-14) | 4 yr | Intravenous: 5-42 days<br>Oral: 0-34 days | 25 days |
| 14 | Weigl et al.[16] (2016) | Arthrocentesis | 42 | Male: 18 | | Without surgery: 7.44 yr<br>With surgery: 22.7 mo | Without surgery: 9.7 days<br>With surgery: 12.5 days | 1.93 days |
| 15 | Duman et al.[26] (2019) | Arthroscopy | 15 | Male: 9 | 5.2 yr (2-10) | 26.1 mo (24-36) | 34 days (26-45) | 4.2 days (3-7) |
| 16 | Garg et al.[12] (2020) | Arthroscopy | 13 | Male: 8 | 4.4 yr (0.25-8) | 22 mo (4-59) | | |
| 17 | Essa et al.[29] (2022) | Arthrocentesis | 5 | Male: 5 | 4 yr (1-10) | 1 yr | 28.5 days (26-42) | 11.5 days (8-28) |

Values in parentheses indicate ranges.
IQR: interquartile range.

with suboptimal results was restriction of range of motion (clinical) and signs of proximal osteomyelitis (radiological) (Table 4). The highest proportion of these findings was observed more often in the arthrotomy group compared to the arthroscopy or arthrocentesis group.

### 6. Additional Unplanned Procedures

Information regarding the need for additional unplanned procedures was included in one study on arthrotomy and three studies each on arthroscopy and arthrocentesis[8,10,12,13,15,16,21]. The highest overall rate of performance of additional unplanned procedures was observed in the arthrocentesis group (24/207, 11.6%), which was reported in the following studies: Givon et al.[13] (10/34, 29.4%), Journeau et al.[15] (5/43, 11.6%), and Weigl et al.[16] (9/42, 21.4%). In a similar manner, the overall rate for additional surgical procedure was 9.3% and 1.8% for the arthroscopy group and the arthrotomy group, respectively. In the arthroscopy group, studies by Fernandez et al.[10] (4/20, 20.0%), Sanpera et al.[21] (2/12, 16.7%), and Garg et al.[12] (2/13, 15.4%) reported on additional open or arthroscopic surgery. In the arthrotomy group, additional unplanned procedures in the form of corticotomy were reported by Pääkkönen et al.[8].

## DISCUSSION

Involvement of the hip joint is common in septic arthritis in children. The sequalae of untreated or inadequately treated septic arthritis of the hip in children can have grave consequences, and their effects on the joint are more severe compared with other joints[22]. Several strategies can be applied in the management of this condition. The underlying principle is the same for all treatment strategies, early diagnosis, early joint decompression, and adequate antibiotic coverage. Surgical intervention can be helpful for debriding the joint, reducing intra articular pressure, and obtaining additional tissue for further examination; arthrotomy has been the treatment of choice worldwide for many decades[23]. However, with the introduction of various imaging modalities and arthroscopy, arthrocentesis and arthroscopic lavage have once again been recognized as optimal alternatives. There is no consensus regarding the optimal method of joint decompression. The goal of this review was to conduct an analysis of the literature regarding the outcomes of application of various methods of joint decompression in management of septic arthritis of the hip in

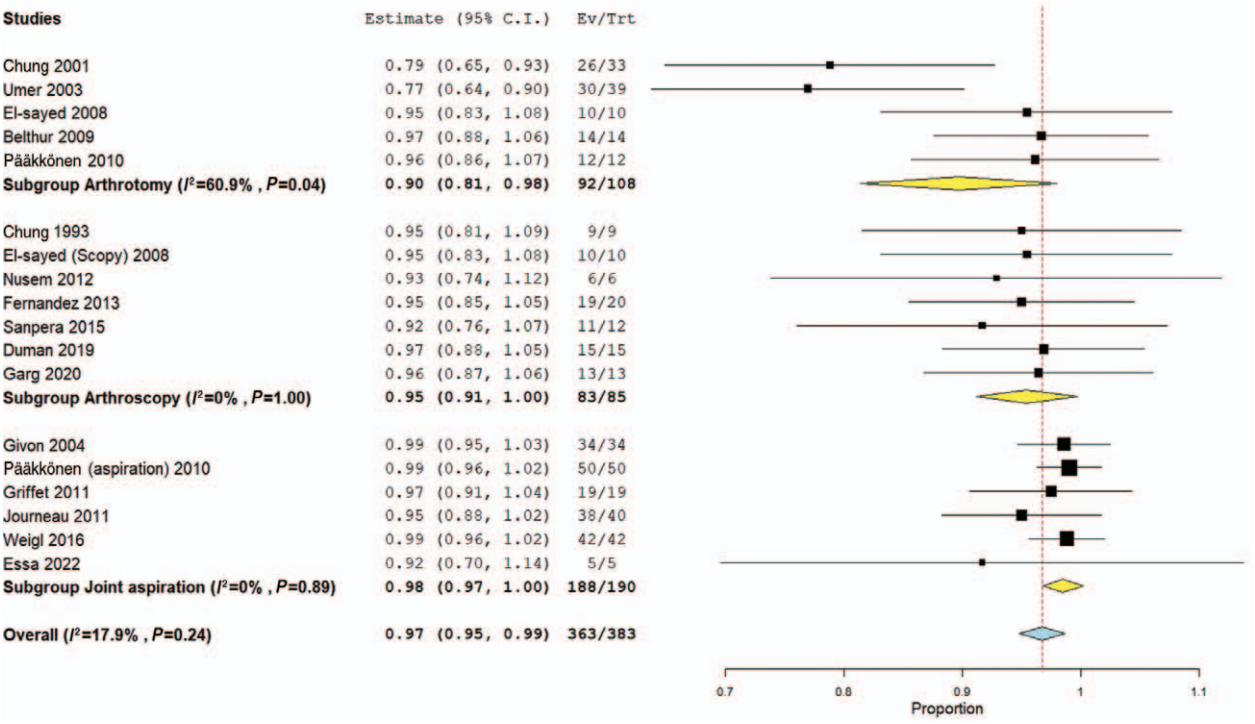


Fig. 2. Forest plot demonstrating the proportional analysis of excellent clinical outcomes in each subgroup. Statistical difference was observed between the proportion of excellent clinical outcomes in arthrotomy (90%, 95% confidence interval [CI] 81-98%) and arthrocentesis (98%, 95% CI 97-100%).

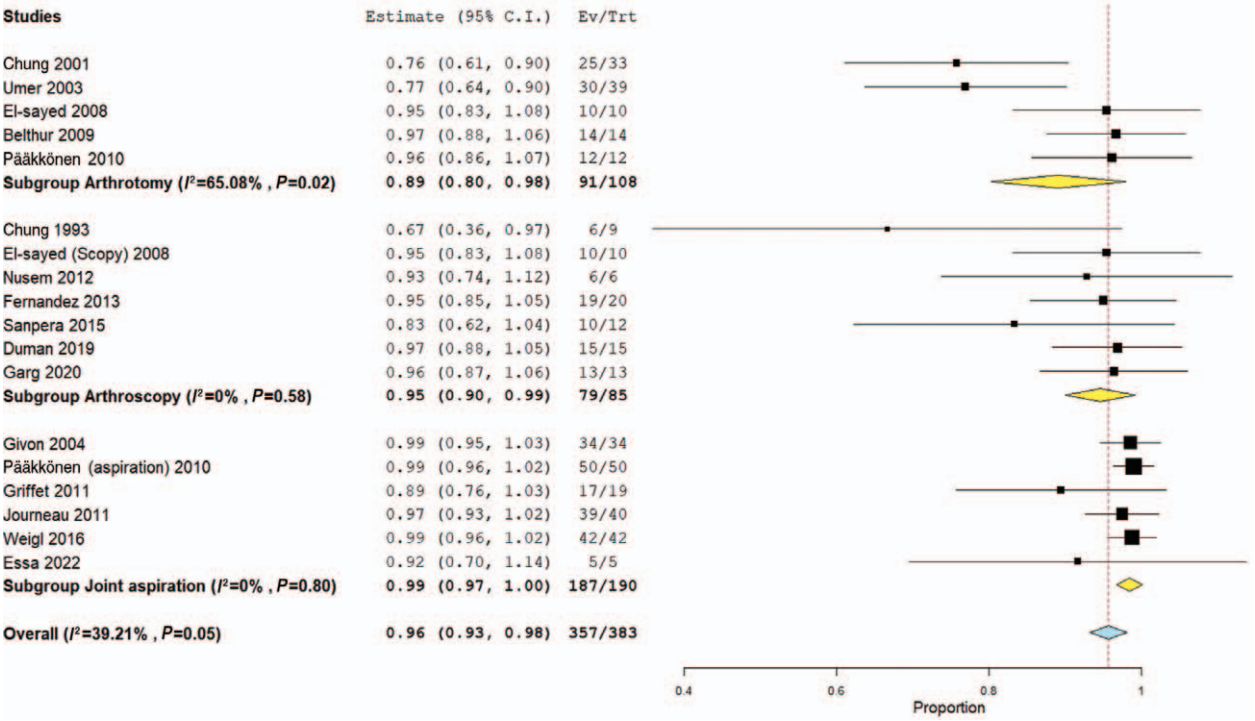


Fig. 3. Forest plot demonstrating the proportional analysis of excellent radiological outcomes in each subgroup. The proportion of excellent radiological outcomes showing a statistical difference between arthrotomy (89%, 95% confidence interval [CI] 80-98%) and arthrocentesis (99%, 95% CI 97-100%) with an intermediate proportion of excellent radiological outcomes in arthroscopy (95%, 95% CI 90-99%).

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**Table 4.** List of Complications, Clinical and Radiological, Noted in the Studies Included

| Method of joint decompression | Study | Clinical complication | Radiological complication |
|---|---|---|---|
| Arthrotomy | Chen et al.[19] (2001) | Hip pain: 7/33, 21.2%<br>Limb length discrepancy: 2/33, 6%<br>Restricted range of motion: 2/33, 6% | Distortion of trabeculae: 5/33, 15.1%<br>Proximal osteomyelitis: 4/33, 12.1%<br>Avascular necrosis of upper femoral physis: 3/33, 9% |
| | Umer et al.[20] (2003) | Restricted range of motion: 10/39, 25.6%<br>Myositis ossificans: 4/39, 10.2% | Growth plate abnormality: 2/39, 5.1%<br>Avascular necrosis of upper femoral physis: 1/39, 2.5% |
| | El-Sayed[7] (2008) | Restricted range of motion: 2/10, 20% | |
| Arthroscopy | Fernandez et al.[10] (2013) | Restricted range of motion: 1/20, 5% | Avascular necrosis of upper femoral physis: 1/20, 5% |
| | Sanpera et al.[21] (2015) | Restricted range of motion: 1/12, 8.3% | Deformity: 1/12, 8.3%<br>Lytic lesion in metaphysis: 1/12, 8.3% |
| Arthrocentesis | Griffet et al.[14] (2011) | | Coxa magna: 1/19, 5.2%<br>Small femoral head: 1/19, 5.2% |
| | Journeau at al.[15] (2011) | | Reduced joint space: 1/43, 2.3% |

children.

In this review it was noted that patients who underwent arthrocentesis had a statistically greater chance of excellent clinical and radiological outcomes. A lower proportion of excellent outcomes was observed for arthroscopy, which was further reduced with consideration of arthrotomy. By contrast, the greatest need for additional unplanned surgical intervention was observed in the arthrocentesis group, followed by the arthroscopy group and the arthrotomy group. Thus, the advantage of an increase in excellent outcomes in patients undergoing arthrocentesis comes with a caveat, that their chances of needing additional unplanned surgical intervention, either in the form of a repeat aspiration or arthrotomy, are greater. The higher percentage of excellent outcomes observed in the arthrocentesis group was due to less associated morbidity. Guided aspiration or continuous aspiration, which ensures better drainage compared with a single blind aspiration of the joint, was used in studies on arthrocentesis. The results observed in the arthrotomy group could be attributed to the higher morbidity associated with an open surgery as well as prolonged healing time compared to arthrocentesis or arthroscopy.

Arthrotomy has remained the choice for decompression and many researchers have concluded that the chances of future sequalae such as avascular necrosis, dislocation, and physeal damage are increased with use of any other mothed[20]. It offers the advantage of being a common procedure that can be performed even in a minimalist set up with limited resources, which is more important in developing countries, where the prevalence of this condition is higher as compared to developed countries. In addition, there is a lower risk of an additional unplanned procedures because visual inspection of the whole joint cavity can be performed to ensure that no pocket of debris is left behind. However, it also has an association with increased morbidity considering the open procedure, which increases healing time and places an additional burden on an already burdened immune system. Compared to a minimally invasive procedure, open surgical intervention in an inflamed hip has been reported to slow down recovery with slower normalization of inflammatory markers[8,24,25]. Intervention after five days and presence of proximal osteomyelitis are two factors noted across many studies to contribute to poor prognosis[19].

With recent advances in arthroscopy, surgeons' preference for arthroscopic lavage in such cases for surgical decompression has increased. This procedure is associated with low morbidity, faster healing, and also enables collection of diseased tissue for further examination[8]. It may be preferred due to reduced hospital stay, earlier return to normal activity, and capacity for visualization without extensive exposure[26]. Its limitations, including cost, a steep learning curve, and maneuvering difficulty in neonates and toddlers, have hindered its widespread acceptance across the globe. Recently published studies have reported on use of the technique in neonates without difficulty in performance of surgery or complication during follow up[12]. The

need for additional unplanned surgical intervention is also a factor in hindering its widespread adaption[10,12,21]. This can mainly be attributed to two factors: delayed presentation and proximal osteomyelitis. Chung et al.[9] attributed the excellent results to the patients who presented within one week of development of symptoms. Although studies proving the superiority of arthroscopy over arthrotomy have been reported, the findings should be interpreted with caution[7,21]. A 70˚ 2.7 mm scope, which provides improved visualization over a 30˚ 5.0 mm scope, is preferred[26]. There is currently no consensus regarding the number of portals (2 vs. 3) and the use of traction (continuous vs. manual)[18,26]. Duman et al.[26] concluded that the use of a sub adductor portal can facilitate visualization of the medial joint space. Physeal separation of the upper femoral physis, triradiate cartilage injury, avascular necrosis, and growth disturbance are potential complications; however, the overall complication rate is similar to that for adults[27]. In a study comparing arthrotomy and arthroscopy, El-Sayed[7] concluded that arthroscopy can be an effective method for application in patients who present early and for surgeons trained in pediatric arthroscopy.

Wilson and Di Paola[28] first reported on use of arthrocentesis in management of septic arthritis of the hip in children. In that study, the criteria for arthrocentesis was age younger than 12 months and duration of symptoms less than four days. Over time, numerous techniques for aspiration of the hip joint showing acceptable results have been reported[8,11,13-16,29]. Unlike arthrotomy, this procedure is not associated with high risk of morbidity, and unlike arthroscopy, it does not require a high level of expertise. Its morbidity is further reduced because general anesthesia is not required in performance of arthrocentesis[13,30]. It offers acceptable joint decompression, pain relief, and rapid return to normal gait without scars or anesthesia. However, parents need to be counselled with regard to repeated aspirations. Drainage can be performed using either the anterior or medial approach. Although sedation is not necessary, Givon et al.[13] reported on use of nitrous oxide sedation, which can be administered by a pediatrician or nurse. Journeau et al.[15] proposed the basic principles for arthrocentesis of the hip in children for management of septic arthritis: (1) the amount of pus aspirated should correspond to ultrasound values, (2) lavage should be performed until clear fluid is obtained and (3) in cases of difficulty in aspiration, an alternative method should be considered. Techniques to enable drainage of thick purulent pus and fibrous debris by performance of arthrocentesis have also been reported[14]. Use of double luminal continuous suction may eliminate the need for repeated aspirations[29].

The importance of antibiotics in management of septic arthritis of the hip in children cannot be overemphasized. Antimicrobial coverage should be administered as soon as samples from blood and joint are collected for culture[31]. The choice of empirical antibiotic should be as per the local antibiogram and a specialty opinion regarding infectious diseases may be obtained. Clindamycin and linezolid are the antibiotics of choice in areas with methicillin-sensitive *S. aureus* endemicity[32]. Once the clinical and biochemical markers show improvement, oral antibiotics can be administered for replacement of the intravenous route. The ideal duration of antibiotic administration has not yet been determined; however, a two-week course of intravenous antibiotics followed by four weeks of oral antibiotics seems reasonable[31,32].

This review has strengths and limitations. The three techniques have become accepted modalities for joint decompression in management of septic arthritis of the hip in children. Only four comparative studies have been reported in the literature thus far. This review attempted to shed light on the outcomes following use of each method of joint decompression. Apart from English, German literature was also screened and included in this review. However, because of the topic considered in the study, it cannot be regarded as an ideal review; this study has weaknesses. The studies were based across different countries, developed and developing, which have their own unique ground reality. As in any surgical specialty, the scope of a randomized controlled trial is significantly diminished as compared to a medical specialty. With involvement of the hip joint, which can have a serious impact on gait as well as future mobility of the patient, there is an inherent selection bias while deciding on treatment. In addition, the current review has its own limitations. All but two of the included studies were retrospective in nature. Heterogeneity regarding patient age and follow-up period was noted across all studies. Due to the heterogeneity among the studies included, the results of the proportional meta-analysis should be interpreted with caution. Important information such as delay in initiation of treatment from the first day of symptoms and severity of illness was not reported in the majority of studies. Information such as the causative organism, which is known to influence outcome in such cases, was missing from the studies.

## CONCLUSION

This review and analysis reports on the outcomes of use of three techniques, arthroscopy, arthrotomy, and arthrocentesis in management of septic arthritis of the hip in children. Patients who underwent arthrocentesis had a statistically greater chance for excellent clinical and radiological outcomes; however, the greatest need for additional unplanned surgical intervention was observed in the arthrocentesis group, followed by the arthroscopy group and the arthrotomy group. Future conduct of a prospective multicentric study focusing on the developed and developing world, along with acquisition of data, such as treatment delay and disease severity will enable assessment of the efficacy of one technique over the other by surgeons worldwide.

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## CONFLICT OF INTEREST

The authors declare that there is no potential conflict of interest relevant to this article.

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