

Use of Epidural Analgesia in Children with Neuromuscular Conditions Following Hip Reconstruction

Sean Tabaie¹, Kevin Cho², Aribah Shah², Omar Tarawneh⁵, Grace Blaylock⁴, Evan Sheppard⁵

1. Orthopaedic Surgery, Children's National Hospital, Washington DC, USA 2. Orthopaedic Surgery, George Washington University School of Medicine and Health Sciences, Washington DC, USA 3. School of Medicine, New York Medical College, Westchester, USA 4. Orthopaedic Surgery, Children's Hospital of Philadelphia, Philadelphia, USA 5. Sheikh Zayed Institute for Pediatric Surgical Innovation, Children's National Health System, Washington, USA

Corresponding author: Sean Tabaie, tabaiesa@gmail.com

Abstract

Background

Neuromuscular conditions, such as Cerebral Palsy, are the most common motor disabilities in the pediatric population. Children with these conditions frequently have accompanying hip deformities that require pelvic and femur osteotomy to correct the spastic hip dislocations. However, postoperative pain management remains an elusive and challenging problem. The purpose of this study was to determine whether postoperative use of epidural analgesia in patients with neuromuscular conditions provided similar outcomes with regards to pain scores, length of stay, duration of foley placement, duration of pain control, and complications as compared to traditional pain management regimens. To our knowledge, this is the first study comparing the use of epidural analgesia to conventional pain relief modalities following hip reconstruction in patients with neuromuscular conditions.

Methods

A retrospective cohort study was performed using records of pediatric patients with neuromuscular conditions treated at our tertiary care center between January 2009 and December 2019. Patients with neuromuscular conditions treated with epidural or non-epidural analgesia for pain relief following unilateral or bilateral proximal femoral osteotomies, pelvic osteotomies, or open hip reduction were eligible for study inclusion. Multiple linear regression was used to determine differences in length of stay, pain score, pain modality, duration of Foley placement, and complications between the two cohorts.

Results

Seventy patients met inclusion criteria for the study. In all, 58 patients underwent unilateral procedures, of which 30 (52%) received epidural analgesia, and 28 (48%) received non-epidural pain control modalities. Demographic and baseline characteristics were similar among the cohort, except for BMI, which varied slightly. Average pain scores and pain control duration were not statistically different between the pain control modalities. After controlling for demographics, procedure, and immobilization type, the epidural group experienced significantly increased length of stay (+3.18 days, $P=0.032$) and duration of Foley placement (+1.04 days, $P=.013$). Complication rates between the two groups were not statistically significant.

Conclusions

The use of epidural analgesia in children with neuromuscular conditions was associated with comparable pain scores, despite the increased length of stay and duration of foley placement. No statistically significant difference in complication rates was observed between patients receiving epidural anesthesia and those receiving traditional pain modalities.

Categories: Anesthesiology, Pain Management, Orthopedics

Keywords: complications, postoperative pain, cerebral palsy, hip surgery, epidural analgesia

Introduction

Neuromuscular conditions, such as Cerebral Palsy (CP), represent a heterogeneous group of permanent motor disorders that appear early in life. Prevalence rates suggest CP occurs at a rate ranging from 1 to 4 per 1000 births making it the most common childhood motor disorder. Although the etiology remains unclear, CP is an upper motor neuron disease that results from insult to the brain during early development [1]. In addition to intellectual disability, affected children frequently experience a variety of musculoskeletal complications, including hip subluxation and displacement as a result of asymmetric muscle imbalances,

and deformity of the femoral head and acetabulum [2].

Decreased range of motion, pain, and joint contractures are also characteristic of CP, with one of the most common locations being the hip. Depending on the severity, musculoskeletal manifestations can result in modest impairment or severe disability affecting the patient's posture, gait, and participation in activities [3]. Moreover, incidence of hip dislocation directly correlates with Gross Motor Function Classification System (GMFCS) level [4]. The musculoskeletal manifestations of cerebral palsy therefore pose a tremendous challenge for the orthopaedic surgeon. Given the lack of curative therapy, much of the lifelong treatment emphasizes reducing pain and improving the child's quality of life. Non-operative treatment includes physical therapy, antispasmodics such as Botulinum Toxin, and bracing. When operative correction is indicated, proximal femur osteotomy and pelvic osteotomy can be performed to relieve joint contractures and correct spastic hip dislocations.

Post-surgical treatment of pain, in these often cognitively impaired children, also represents a significant challenge. Most of these patients suffer from severe intellectual delay and often have issues with communication and, therefore, cannot self-report their pain [5-7]. Since most current forms of pain assessment rely on self or parent reporting, these patients are at risk for being inadequately treated for their pain. While undertreated pain leads to patient suffering, overtreatment can lead to respiratory compromise in an already vulnerable population [5, 7-8]. In patients with neuromuscular conditions undergoing spine surgery, epidural analgesia has been shown to decrease intensive care unit admissions due to respiratory decompensation [8-9]. To mitigate the respiratory complications associated with scheduled opioid use in this population, many centers have begun using epidural anesthesia in addition to narcotics for children undergoing lower extremity surgery. Coadministration of epidural opioids and local anesthetics allows for a reduction in drug dosage for both medications, clinically similar efficacy in pain control, and a reduction in drug-related adverse effects [10]. However, patient-controlled analgesia (PCA) remains a widely used postoperative pain control modality. Chauvin et al. found that while there was a considerable reduction in drug (alfentanil) consumption in the epidural group compared to the PCA group, the incidence of oxyhemoglobin desaturation between the two groups remained similar [10-11]. Another study showed no significant differences in the incidence of drug-related complications, such as over-sedation and respiratory depression between epidural and PCA groups, but did note a modest improvement in analgesia [9]. However, Moore et al. and Duarte et al., showed that epidural analgesia significantly improved pain control and decreased respiratory depression [8].

Epidural analgesia is often continued for two to three days post surgery, depending on institution protocols [12]. During this time, a Foley catheter is left in place until the epidural catheter is discontinued. Due to the inability to direct neural-blockade to a single extremity, physical therapy is often delayed, resulting in longer hospital stays. While many studies have compared the effectiveness of epidural and non-epidural pain control modalities in both pediatric and adult populations for various surgical procedures, this study is the first to compare these modalities in patients with neuromuscular conditions undergoing unilateral hip reconstruction. We hypothesized that patients whose pain was controlled with a non-epidural analgesia would have the same level of pain control, no differences in respiratory complications, but shorter length of stay, and shorter duration of foley placement compared to those treated with epidural analgesia. This study sought to determine if epidural analgesia used for patients with neuromuscular conditions undergoing hip reconstruction (proximal femur osteotomies, acetabular osteotomies, or both) was non-inferior to traditional pain control regimens. Additionally, we sought to quantify differences in pain scores, duration of pain control, duration of Foley placement, and overall complication rate.

Materials And Methods

Following approval from the Institutional Review Board, we performed a retrospective chart review of pediatric hip reconstructive procedures in which either epidural or non-epidural analgesia was administered for postoperative pain relief. We identified patients who underwent unilateral or bilateral proximal femoral osteotomies, pelvic osteotomies, or hip open reductions from 01/01/2009 - 12/02/2019, which yielded 227 patients. We excluded patients who had a revision surgery and those without neuromuscular conditions. The final cohort consisted of 70 cases that met all criteria, of which 58 underwent unilateral procedures. Demographics, laterality of surgery, postoperative pain control modality, duration of pain control modality, length of stay, and postoperative complications were recorded. Pain scores were recorded using the Face, Legs, Activity, Cry, Consolability (FLACC) pain scale. A low, high, median, and mean pain score was recorded for each patient. Complications were defined as readmission to hospital for a respiratory or orthopaedic issue including but not limited to re-dislocation or loss of surgical fixation. Additionally, we included soft-tissue complications, such as pressure ulcers, or any superficial or deep wound infection.

Summary statistics on demographic and baseline patient characteristics were presented as mean with standard deviation for continuous data and frequencies with percentages for categorical data. Continuous and categorical baseline variables were compared between epidural and non-epidural groups using unpaired t-test and Chi-square test or Fisher's exact test (if expected cell count < 5) respectively. Normality assumptions were checked using a statistical test (e.g., Shapiro Wilk test) as well as graphical methods (e.g., histogram, q-q plot). Only the length of stay variable was found to be significantly deviated from normality.

Pain scores, duration of Foley placement, and duration of pain control modality between two groups were compared using unpaired t-test followed by multiple linear regression analysis adjusted for potential confounders age, BMI, procedure type, and immobilization type. Length of stay was compared using non-parametric Mann-Whitney U Test. Complication rates including hospital readmission, respiratory difficulties, re-dislocation, loss of surgical fixation, and soft-tissue complications were compared using Chi-squared test. All statistical tests were two-sided and performed at the 0.05 level of significance. Statistical analysis was performed using R statistical software, version 4.0.0 (R Core Team, 2020).

Results

Of the 70 patients in the dataset, 58 patients underwent unilateral procedures, 28 (48%) used non-epidural pain-control modalities, and 30 (52%) used epidural analgesia. Both groups were comparable in terms of the baseline characteristics except for BMI which was slightly higher in the non-epidural group. (Table 1)

Pain scores (mean, median, high, and low), length of stay, duration of Foley placement, duration of pain control modality, and complications were compared between the two groups. Average pain scores were similar between the two groups. Duration of Foley placement was significantly higher in the epidural group compared to the non-epidural group (P= 0.008). Although complications were higher in the epidural group, it was not statistically significant (26.7% vs. 10.7%, P= 0.121) (Table 2).

We further compared these variables between two groups using multiple linear regression adjusted for age, BMI, procedure type, and immobilization type. This adjusted analysis revealed that length of stay and duration of Foley placement was significantly higher and Pain score low was significantly lower in the epidural group compared to the non-epidural group (Table 3).

Patient characteristics	Overall (N=58)	Epidural (N=30)	Non-epidural (N=28)	P value
Age (years), mean (SD)	9.5 (5.7)	8.8 (4.5)	10.2 (6.9)	0.358
Height (cm), mean (SD)	119.4 (24.0)	119.3 (23.4)	119.5 (25.0)	0.975
Weight (kg), mean (SD)	26.3 (11.9)	24.6 (10.2)	28.1 (13.3)	0.259
BMI (kg/m ²), mean (SD)	17.4 (3.9)	16.0 (3.4)	18.8 (3.8)	0.006
ASA, n (%) Class 1 Class 2 Class 3 Class 4	1 (2.2) 7 (15.6) 36 (80.0) 1 (2.2)	1 (4.0) 3 (12.0) 21 (84.0) 0 (0.0)	0 (0.0) 4 (20.0) 15 (75.0) 1 (5.0)	0.663
Immobilization Type, n (%) Petrie Pillow Spica	20 (37.7) 9 (17.0) 24 (45.3)	7 (25.0) 7 (25.0) 14 (50.0)	13 (52.0) 2 (8.0) 10 (40.0)	0.078
Procedure, n (%) Combined Femur Hip	37 (63.8) 13 (22.4) 8 (13.8)	16 (53.3) 10 (33.3) 4 (13.3)	21 (75.0) 3 (10.7) 4 (14.3)	0.112
Open Reduction, n (%)	28 (48.3)	15 (50.0)	13 (46.4)	0.993
Number of comorbidities, mean (SD)	6.3 (2.8)	6.6 (3.0)	6.0 (2.6)	0.445

TABLE 1: Demographic and baseline patient characteristics

* SD= Standard deviation

* P-values were obtained from unpaired t-test for continuous data, and Chi square/Fisher's exact test for categorical data

Variables	Epidural (N=30)	Non-epidural (N=28)	P value
Pain Score Mean, mean (SD)	3.5 (1.1)	3.7 (0.8)	0.446
Pain Score Median, mean (SD)	3.5 (1.4)	3.5 (1.1)	0.881
Pain Score High, mean (SD)	6.0 (2.1)	6.4 (1.9)	0.536
Pain Score Low, mean (SD)	1.3 (0.7)	1.8 (1.2)	0.070
Length of Stay (days), median (IQR)	4.6 [3.8, 6.2]	3.3 [3.0, 6.2]	0.171
Foley Duration (days), mean (SD)	2.7 (1.0)	1.8 (1.3)	0.008
Pain Control Duration (days), mean (SD)	2.5 (1.0)	2.0 (1.9)	0.276
Complications, n (%)	8 (26.7)	3 (10.7)	0.121

TABLE 2: Comparison of pain scores, length of stay, Foley catheter duration, pain control modality, and complications

* IQR= Interquartile Range

* P-values were obtained from unpaired t-test or Mann-Whitney U Test (if skewed) for continuous data, and Chi square test for categorical data

Variables	Difference (95% CI) [Epidural - Non-Epidural]	P value
Pain Score Mean	-0.06 (-0.69, 0.57)	0.846
Pain Score Median	0.13 (-0.64, 0.89)	0.737
Pain Score High	0.26 (-1.11, 1.64)	0.699
Pain Score Low	-0.77 (-1.42, -0.11)	0.022
Length of Stay (days)	3.18 (0.28, 6.07)	0.032
Foley Duration (days)	1.04 (0.23, 1.84)	0.013
Pain Control Duration (days)	0.11 (-1.13, 1.35)	0.854

TABLE 3: Multiple linear regression analysis adjusted for age, BMI, procedure type, and immobilization type

* CI= Confidence interval

Discussion

After controlling for demographic variability, our data suggest there are significant differences in the length of stay, duration of foley placement, and the lowest reported pain score between the epidural and non-epidural groups. The multiple linear regression analysis showed that the epidural group had a statistically significant increase in length of stay and duration of foley placement, and significantly lower pain score than the non-epidural group ($P=0.032$, $P=0.013$, $P=0.022$), but there were no significant differences in any of the other pain score parameters. These results demonstrate that the pain control is comparable between epidural and non-epidural analgesia, but that epidural analgesia has the additional drawbacks of increasing length of stay and duration of foley placement in this patient population. While the difference in lowest pain score values between the groups were statistically significant, no significant conclusions can be drawn from this particular parameter, as the other pain score parameters were not statistically significant, and an inherent shortcoming of parameters such as high, low, and mean the values are biased due to outliers.

Patients receiving epidural analgesia maintained their Foley catheter an average of 1.04 more days than the non-epidural patients, which could pose a greater risk of complications related to catheterization such as urinary tract infection.^{20,21} Additionally, patients receiving epidural analgesia had a length of stay that was on average 3.18 days greater than the non-epidural group. Increased length of stay is associated with a

number of negative health consequences, such as increased mortality, increased risk of infection, increased risk of adverse medication side effects, and decreased quality of care [13-14]. Furthermore, several studies have shown that epidural analgesia has a high failure rate [12,15-20].

Although the difference in the number of complications between the two groups was not statistically significant, the increased number of complications in the epidural cohort is important to note. More specifically, placement of an epidural catheter has been shown to potentially further increase the risk of adverse complications, including epidural abscess, epidural hematoma, and post dural puncture headache [18]. At the same time, none of the epidural patients included in this study experienced these described complications as a result of catheterization. Alternatively, a systematic review by Guay et al. showed that there were no conclusive differences in the risk of complications such as respiratory depression, epidural abscess, wound infection, or neurological complications between epidural and non-epidural groups in the acute setting for postoperative pain control following thoraco-lumbar spine surgery in children [15].

Prior studies have compared epidural and non-epidural (PCA) pain control modalities, but the literature is inconclusive on whether epidural analgesia offers any additional benefit to postoperative treatment when compared to traditional multimodal pain control regimens. Chauvin et al. demonstrated that epidural administration of alfentanil resulted in a 39% decrease in opioid consumption as compared to the non-epidural PCA modality, but ultimately, the oxyhemoglobin desaturation between the two groups was comparable [10-11].

Other studies suggest no significant differences in the incidence of drug-related complications, such as over-sedation, oxygen desaturation, and respiratory depression between epidural and PCA groups, and describe a modest improvement in analgesia [21]. However, Moore et al. and Duarte et al., showed that epidural analgesia significantly improved pain control and decreased incidence of respiratory depression compared to non-epidural analgesia [8, 16].

The results of this study corroborate the limited existing literature on epidural versus non-epidural pain control. However, the present study has several limitations. Of note, given our study's retrospective nature, there was a lack of randomization among our sample, which may pose a selection bias. Additionally, although baseline demographic characteristics were not significantly different, our sample had a wide spectrum of BMI recordings which poses a challenge in ruling out possible comorbidities influencing our findings. Furthermore, pain scores obtained from our patient sample are limited by the difficulty of attaining pain scores from children with neuromuscular conditions, such as cerebral palsy, given their inability to reliably self-report pain location and intensity.

Studies suggest that children with CP already experience twice as many complications and have high reoperation rates following hip surgery compared to their non CP counterparts [22-23]. Therefore, to optimize outcomes in an already at-risk patient population likely to undergo multiple procedures to correct musculoskeletal abnormalities, it is crucial to minimize narcotic usage given its addictive nature and side effects such as constipation, sedation, and tolerance. We believe the present study can serve as a foundation for future prospective and multi center studies, which should aim to investigate dose and timing of epidural analgesia in children with neuromuscular conditions with a particular focus on surgical approach, side effects, and time to return to activity.

Conclusions

Use of epidural analgesia in children with neuromuscular conditions was associated with comparable pain scores, despite the increased length of stay and increased duration of foley placement. No statistically significant difference in complication rates was observed between patients receiving epidural anesthesia and those receiving traditional pain modalities. Given the paucity of data surrounding the use of epidural anesthesia in children with neuromuscular conditions, future research should seek to further investigate the efficacy of epidural analgesia for postoperative pain management in children with neuromuscular conditions.

Additional Information

Disclosures

Human subjects: Consent was obtained or waived by all participants in this study. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** Sean Tabaie declare(s) personal fees from OrthoPediatrics. Sean Tabaie declare(s) personal fees from J&J Depuy Synthes. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

References

1. Stavsky, Mor, Mastroia, et al.: Cerebral Palsy-Trends in Epidemiology and Recent Development in Prenatal Mechanisms of Disease, Treatment, and Prevention. *Front Pediatr*. 2017, 5:21. [10.3389/fped.2017.00021](https://doi.org/10.3389/fped.2017.00021)
2. Boldingh, EJ, Bouwhuis, CB, van der Heijden-Maessen: HCM, Bos, CF, Lankhorst, GJ: Palliative hip surgery in severe cerebral palsy: a systematic review. *J Pediatr Orthop B*. 2014, 23:86-92.
3. Marcström, A, Hägglund, G, Aliksson-Schmidt: AI: Hip pain in children with cerebral palsy: a population-based registry study of risk factors. *BMC Musculoskelet Disord*. 2019, 20:62. [10.1186/s12891-019-2449-8](https://doi.org/10.1186/s12891-019-2449-8)
4. Soo, B, Howard: JJ, Boyd, RN, Reid, SM, Lanigan, A, Wolfe, R, Reddihough, D, Graham, HK: Hip displacement in cerebral palsy. *J Bone Joint Surg Am*. 2006, 88:121-129. [10.2106/JBJS.E.00071](https://doi.org/10.2106/JBJS.E.00071)
5. Hauer, J, Houtrow: AJ Section on Hospice And Palliative Medicine, Council on Children with Disabilities Pain Assessment and Treatment in Children With Significant Impairment of the Central Nervous System. *Pediatrics*. 2017, 139:[10.1542/peds.2017-1002](https://doi.org/10.1542/peds.2017-1002)
6. Xu N, Matsumoto H, Roye D, et al.: Post-Operative Pain Assessment and Management in Cerebral Palsy (CP): A Two-Pronged Comparative Study on the Experience of Surgical Patients. *J Pediatr Nurs*. 2019, 46:10-14. [10.1016/j.pedn.2019.01.014](https://doi.org/10.1016/j.pedn.2019.01.014)
7. McKernan, KA, Kieckhefer, GM, Engel: JM, Jensen, MP, Labyak, S: Pain in children with cerebral palsy: a review. *J Neurosci Nurs*. 2004, 36:252-259. [10.1097/01376517-200410000-00004](https://doi.org/10.1097/01376517-200410000-00004)
8. Moore RP, Wester T, Sunder R, Schrock C, Park TS: Peri-operative pain management in children with cerebral palsy: comparative efficacy of epidural vs systemic analgesia protocols. *Paediatr Anaesth*. 2013, 23:720-725. [10.1111/pan.12187](https://doi.org/10.1111/pan.12187)
9. Kjeldgaard Pedersen L, Nikolajsen L, Rahbek O, Uldall Duch B, Møller-Madsen B: Epidural analgesia is superior to local infiltration analgesia in children with cerebral palsy undergoing unilateral hip reconstruction. *Acta Orthop*. 2016, 87:176-182. [10.3109/17453674.2015.1113375](https://doi.org/10.3109/17453674.2015.1113375)
10. de Leon-Casasola, Oscar A. MD; Lema, Mark J. PhD, MD: Postoperative Epidural Opioid Analgesia: What Are the Choices?. *Anesthesia & Analgesia*: October. 1996, 83:867-875. [10.1097/00005539-199610000-00038](https://doi.org/10.1097/00005539-199610000-00038)
11. Chauvin M, Hongnat JM, Mourgeon E, et al.: Equivalence of postoperative analgesia with patient-controlled intravenous and epidural alfentanil. *Anesth Analg*. 1993, 76:1251-8. [10.1213/00000559-199306000-00012](https://doi.org/10.1213/00000559-199306000-00012)
12. Gauger VT, Voepel-Lewis TD, Burke CN, et al.: Epidural analgesia compared with intravenous analgesia after pediatric posterior spinal fusion. *J Pediatr Orthop*. 2009, 29:588-593. [10.1097/BPO.0b013e3181b2ba08](https://doi.org/10.1097/BPO.0b013e3181b2ba08)
13. Baek H, Cho M, Kim S, Hwang H, Song M, Yoo S: Analysis of length of hospital stay using electronic health records: A statistical and data mining approach. *PLoS One*. 2018:0195901-2018. [10.1371/journal.pone.0195901](https://doi.org/10.1371/journal.pone.0195901)
14. Lingsma HF, Bottle A, Middleton S, Kievit J, Steyerberg EW, Marang-van de Mheen PJ: Evaluation of hospital outcomes: the relation between length-of-stay, readmission, and mortality in a large international administrative database. *BMC Health Serv Res*. 2018:116-2018. [10.1186/s12913-018-2916-1](https://doi.org/10.1186/s12913-018-2916-1)
15. Guay J, Suresh S, Kopp S, Johnson RL: Postoperative epidural analgesia versus systemic analgesia for thoraco-lumbar spine surgery in children. *Cochrane Database Syst Rev*. 2019:11, 012819-2019. [10.1002/14651858.CD012819.pub2](https://doi.org/10.1002/14651858.CD012819.pub2)
16. Duarte LT, Fernandes Mdo C, Costa VV, Saraiva RA: Incidência de depressão respiratória no pós-operatório em pacientes submetidos à analgesia venosa ou peridural com opioides [The incidence of postoperative respiratory depression in patients undergoing intravenous or epidural analgesia with opioids]. *Rev Bras Anesthesiol*. 2009, 59:409-420. [10.1590/s0054-70942009000400003](https://doi.org/10.1590/s0054-70942009000400003)
17. Sucato DJ, Duey-Holtz A, Elerson E, et al.: Postoperative analgesia following surgical correction for adolescent idiopathic scoliosis: a comparison of continuous epidural analgesia and patient-controlled analgesia. *Spine*. 2005, 30:211-217. [10.1097/01.brs.0000150832.53604.64](https://doi.org/10.1097/01.brs.0000150832.53604.64)
18. Wheatley RG, Schug SA, Watson D: Safety and efficacy of postoperative epidural analgesia . *Br J Anaesth*. 2001, 87:47-61. [10.1093/bja/87.1.47](https://doi.org/10.1093/bja/87.1.47)
19. Shea J, Nunally KD, Miller PE, et al.: Hip Reconstruction in Nonambulatory Children With Cerebral Palsy: Identifying Risk Factors Associated With Postoperative Complications and Prolonged Length of Stay. *J Pediatr Orthop*. 2020, 40:972-977. [10.1097/BPO.0000000000001643](https://doi.org/10.1097/BPO.0000000000001643)
20. Ma Y, Lu X: Indwelling catheter can increase postoperative urinary tract infection and may not be required in total joint arthroplasty: a meta-analysis of randomized controlled trial. *BMC Musculoskelet Disord*. 2019:11-2019. [10.1186/s12891-018-2395-x](https://doi.org/10.1186/s12891-018-2395-x)
21. Nicolle LE: Catheter associated urinary tract infections . *Antimicrob Resist Infect Control*. 2014:3, 23-2014. [10.1186/2047-2994-3-23](https://doi.org/10.1186/2047-2994-3-23)
22. DiFazio R, Vessey JA, Miller P, Van Nostrand K, Snyder B: Postoperative Complications After Hip Surgery in Patients With Cerebral Palsy: A Retrospective Matched Cohort Study. *J Pediatr Orthop*. 2016, 36:56-62. [10.1097/BPO.0000000000000404](https://doi.org/10.1097/BPO.0000000000000404)
23. Schmale GA, Eilert RE, Chang F, Seidel K: High reoperation rates after early treatment of the subluxating hip in children with spastic cerebral palsy. *J Pediatr Orthop*. 2006, 26:617-23. [10.1097/01.bpo.0000235391.26666.b0](https://doi.org/10.1097/01.bpo.0000235391.26666.b0)