# What's New in Pediatric Hip?

*Matthew R. Schmitz, MD,* Todd J. Blumberg, MD,† Susan E. Nelson, MD, MPH,‡ Julieanne P. Sees, DO,§ and Wudbhav N. Sankar, MD‖*

**Background:** Developmental dysplasia of the hip (DDH), which encompasses a wide spectrum of disease from mild dysplasia to frank dislocation, is one of the most common developmental deformities of the lower extremities and one of the leading causes of future osteoarthritis and hip arthroplasty. Legg-Calvé-Perthes disease (LCPD) results from a vascular insult to the growing femoral epiphysis, which in turn can create permanent morphologic changes to the hip joint. Slipped capital femoral epiphysis (SCFE) occurs when the proximal femoral physis fails allowing the epiphysis to displace in relation to the metaphysis. Infections about the hip also create significant morbidity in the pediatric hip.

**Methods:** We searched the PubMed database for all studies related to DDH, LCPD, SCFE, and pediatric hip infections that were published between July 1, 2014 and August 31, 2017. The search was limited to English articles and yielded 839 papers. This project was initiated by the Pediatric Orthopaedic Society of North America Publications Committee and was reviewed and approved by the Pediatric Orthopaedic Society of North America Presidential Line.

**Results:** A total of 40 papers were selected for review based upon new and significant findings. Select historical manuscripts are also included to provide sufficient background information.

**Conclusions:** DDH, LCPD, SCFE, and infections about the hip continue to be important topics in pediatric orthopaedics and areas of vital research. This manuscript reviews the most important recent literature on the diagnosis and treatment of these pediatric hip conditions.

**Level of Evidence:** Level V.

**Key Words:** developmental dysplasia of the hip, DDH, Legg-Calvé-Perthes disease, SCFE, slipped capital femoral epiphysis, septic hip, osteomyelitis

(*J Pediatr Orthop* 2018;00:000–000)

From the *Department of Orthopaedics, San Antonio Military Medical Center, San Antonio, TX; †Department of Orthopaedics and Sports Medicine, Seattle Children's Hospital, Seattle, WA; ‡Department of Orthopaedics and Rehabilitation, University of Rochester and the Golisano Children's Hospital at Strong, Rochester, NY; §Department of Orthopaedic Surgery, Nemours Alfred I Dupont Hospital for Children, Wilmington, DE; and ‖Division of Orthopaedic Surgery, Children's Hospital of Philadelphia, Philadelphia, PA.

No funding was received for the completion of this manuscript.

The authors declare no conflicts of interest.

Reprints: Wudbhav N. Sankar, MD, Division of Orthopaedic Surgery, The Children's Hospital of Philadelphia, 34th Street and Civic Center Boulevard, Wood Building, 2nd Floor, Philadelphia, PA 19104. E-mail: sankarw@email.chop.edu.



DOI: 10.1097/BPO.0000000000001166

Infantile developmental dysplasia of the hip (DDH) encompasses a wide spectrum of disease from mild dysplasia of the acetabulum to frank dislocation of the hip joint, and is one of the most common developmental deformities of the lower extremity. Legg-Calvé-Perthes disease (LCPD) refers to idiopathic avascular necrosis (AVN) of the proximal femoral epiphysis in a growing child, and continues to be an area of treatment controversy. Slipped capital femoral epiphysis (SCFE) occurs when the proximal femoral epiphysis displaces in relation to the metaphysis through failure of the physis. Morbidity can result from osteonecrosis (for unstable slips) and/or morphologic changes to the proximal femur that limit functional range of motion and create impingement. Bony or soft tissue infections can also be a source of significant morbidity in the pediatric hip.

The "What's New in …" series of articles in the *Journal of Pediatric Orthopaedics* has been endorsed by the POSNA Presidential Line. Authors have been vetted by the POSNA Publications Committee to provide experts in each subspecialty area and to minimize any potential personal conflicts of interest. All review articles of this type undergo the full journal review process to ensure the highest quality information.

## METHODS

This project was initiated by the Pediatric Orthopaedic Society of North America Publications Committee. The manuscript was reviewed and approved by the Pediatric Orthopaedic Society of North America Presidential Line before submission to this journal to insure a consistent and uniform message from the Society on this topic. To conduct this review, we searched the PubMed database for the following terms: dysplasia, hip, congenital, perthes, DDH, Legg-Calvé-Perthes, slipped capital femoral epiphysis, slipped upper femoral epiphysis, SCFE, pediatric septic hip, septic arthritis, osteomyelitis, and hip infection. Papers between July 1, 2014 and August 31, 2017. The search was limited to English articles and yielded 839 papers. Of these studies, 40 were identified as having contributed important new findings.

## RESULTS

### DDH

Developmental dysplasia of the infant hip (DDH) continues to be a focus of much research, with several studies reviewing risk factors, radiographic work-up, management, and long-term effects. With regards to ultrasound screening in preterm infants, Lee et al[1] found low rates of ultrasonographic DDH in infants <32 weeks

gestational age (2%), and all findings normalized on follow-up ultrasound, suggesting that routine screening of preterm infants should not necessarily be performed. Multiple authors also compared the Tönnis classification to a new radiographic classification proposed by the International Hip Dysplasia Institute (IHDI) for infants with DDH. Both Ramo et al[2] and Miao et al[3] found that the IHDI classification was easier to use with better interrater agreement while still maintaining prognostic implications for treatment.

Pavlik harness (PH) treatment has also been reviewed in the recent literature. A multicenter prospective trial evaluating the use of brace treatment found an overall success rate of 79% for dislocated hips. A majority of the hips were treated using a PH (93%), and risk factors for failure included the development of a femoral nerve palsy, use of a static brace, a clinically irreducible hip on presentation, initiating treatment after 7 weeks, Graf IV severity (dislocated hip with labrum displaced downward and alpha angle <43 degrees), and right sided hip dislocations.[4] Ortolani positive hips under 6 months of age were also retrospectively reviewed and showed no difference in success rates for patients wearing the harness full time (never removing the harness) versus 23 h/d, or any difference in success rates for patients with weekly follow-up versus those seen once or twice during the first 4 weeks of treatment.[5] With regards to timing of PH treatment, Larson et al[6] reviewed all hips with ultrasonographic DDH and examination findings of instability and showed no difference in failure rates for PH treatment when initiated before or after 30 days suggesting that there is no downside to waiting 30 days to institute treatment. However, Omeroglu et al[7] showed that PH treatment became less effective in children with increasing age, noting a 4-month threshold after which initiating treatment increased the risk of failure. Novais et al[8] also analyzed potential reasons for PH failure and found that treatment failed in 27% of their Ortolani positive hips with Graf IV class being an independent risk factor for failure of treatment.

Multiple authors also reviewed surgical treatment for DDH. In a prospective study by the IHDI across 7 institutions, Sankar and colleagues reviewed 87 hips that underwent an attempt at closed reduction in the operating room. Thirty-one of 87 (36%) had failed previous treatment with harness or brace while 64% had no previous treatment. The authors showed 9% of the hips could not be reduced initially and for the remaining 79 hips, 7 hips (9%) went on to redislocate between 1 and 6 months postoperatively. In addition, of the 72 hips that were successfully treated with closed reduction, 25% developed evidence of AVN at a median of 22-month follow-up. The authors also found that 11% of the successful closed reductions went on to have osteotomies of the acetabulum and/or femur for residual dysplasia.[9] In another study, Schur et al[10] found a 35% AVN rate (29/82 hips) after closed reduction and spica casting at 5-year follow-up, although the authors did not comment on the grading or staging of AVN. Despite those relatively high rates of AVN, Bradley et al,[11] in a systematic review of 538 hips that had undergone closed reduction, found that the overall rate of significant AVN (types II to IV in both the Kalmachi/MacEwan and Bucholz/Ogden grading schemes) was only 10% at 7.6-year follow-up. When investigating whether the presence of an ossific nucleus has an effect on the rate of AVN following closed reduction, both Chen et al[12] and Niziol et al[13] performed meta-analyses that showed no protective effect for delaying closed reduction until appearance of the ossific nucleus. With regards to longer term outcomes in surgically treated hips, Gardner et al[14] showed that there was a relatively high rate of AVN following medial open reduction at an average follow-up of 10 years, with 32.9% of hips developing at least grade 2 AVN and long-term outcome being unsatisfactory in 26% of those cases which developed AVN. In addition, in 2 separate studies, Yilmaz and colleagues evaluated the fate of the iliopsoas muscle in long-term follow-up after open reduction via medial approach with complete tenotomy. At an average of 16-year follow-up, they found via magnetic resonance imaging (MRI) that spontaneous reattachment occurred in 90% of study subjects.[15] They also found flexor muscle strength was decreased against low resistance but forceful flexor muscle strength was retained.[16]

## LCPD

Recent developments in the treatment of LCPD have focused on improving the assessment and quantification of epiphyseal involvement, with the goal of obtaining earlier prognostic information to optimize treatment and timing for intervention on hips likely to end up with substantial deformity. The use of perfusion magnetic resonance imaging (pMRI), a gadolinium-enhanced technique that provides qualitative information regarding epiphyseal blood flow, is being studied as one method of obtaining earlier prognostic information. Kim et al[17] utilized pMRI during initial and early fragmentation stages and found that both total and lateral third epiphyseal perfusion were predictive of the ultimate lateral pillar involvement, potentially allowing for earlier identification of hips at higher risk for a poor outcome. Another study utilizing pMRI was performed to assess revascularization of the femoral head with serial pMRI.[18] Results demonstrated that revascularization proceeded in a common pattern, beginning at the periphery of the epiphysis and converging toward the anterocentral region with time, confirming previous studies performed with scintigraphy.[19,20] While the indications for pMRI in Perthes disease are still being defined, the ability to better understand the natural history of this condition and the underlying pathomechanisms that result in revascularization of the femoral epiphysis ultimately may improve our understanding and ability to treat this condition.

In addition to imaging advancements in the evaluation of epiphyseal perfusion, investigators have also been able to quantitate hip inflammation and correlate this with levels of synovial inflammatory cytokines.[21] Utilizing serial pMRIs, the authors found that total synovial volume in patients with Perthes disease increased 5-fold on average, and interleukin-6 was correspondingly elevated in affected hips. These findings are significant because of the

strong correlation between interleukin-6 and bone resorption in other inflammatory conditions. Further study is needed to understand the implications of proinflammatory cytokines and the bony resorption that occurs during the fragmentation stage of Perthes disease.

Many studies have focused on evaluating outcomes of Perthes hips following both operative and nonoperative management. One study evaluated treatment with varus derotational osteotomy (VDRO) at a mean of 42.5 years of follow-up.[22] The authors evaluated a number of variables, in an attempt to identify predictors of improved radiographic and patient-reported outcomes at long-term follow-up after VDRO. The authors identified that across patients treated with VDRO, those with Stulberg class I or II hips had significantly better long-term outcomes than those with Stulberg classes III to V. Patients with Stulberg I or II hips were more likely to have had VDRO at a younger age (6.88 vs. 8.76 y) and were associated with better Harris hip scores (93.2 vs. 56.5) and SF-36 scores (85.5 vs. 55.4). The long-term follow-up of Perthes patients demonstrates the validity of Stulberg classification at skeletal maturity and correlation with long-term outcomes.

Intermediate-term outcomes were evaluated after combined pelvic and femoral osteotomies in patients with LCPD.[23] Sixty-nine patients underwent the combined procedures with mean follow-up of 10.8 years. While mean Harris hip score was 90 and 87% of patients reported an excellent or good clinical result, these results are similar to patients who underwent either a pelvic or a proximal femoral osteotomy alone. In addition, only 52% of patients with a double osteotomy had good radiographic outcome at skeletal maturity (Stulberg classes I and II), further highlighting the challenge of identifying the patients who will benefit from surgical intervention. Additional work evaluating radiographic outcomes for patients with LCPD diagnosed before age 6 was reviewed.[24] With a mean age at diagnosis of 4.5 years, the authors showed 63% of hips in this young cohort to have a good radiographic outcome (Stulberg classes I and II) at 9.5 years average follow-up. Predictors for a better radiographic outcome were maintained abduction and lateral pillar A or B classification, underscoring both the substantial remodeling potential in younger patients with Perthes and the improved prognosis for patients who maintain hip abduction over 30 degrees.

## SCFE

Obesity is an established risk factor for SCFE.[25–27] This is supported by recent population based studies in Sweden and the UK,[28,29] which have reaffirmed the importance of targeted prevention in this area. Given the link between obesity and leptin resistance, and the pathologic similarities seen in the hypertrophic zone of the physis between SCFE and those with elevated leptin, Halverson et al[30] hypothesized a relationship between leptin and SCFE. The authors prospectively studied the association; in a multivariate regression model combining leptin level, obesity status, race, and sex, elevated leptin remained the only patient factor independently associated with a significantly increased odds of developing a SCFE (odds ratio, 4.93; 95% confidence interval, 1.31-18.48; $P < 0.02$). Future research to elucidate the clinical utility of this factor in prevention or prognostication is needed.

AVN is a dreaded complication of SCFE, and monitoring of epiphyseal perfusion has become of interest for both open realignment and in situ pinning of unstable slips. In a descriptive study by Jackson et al,[31] 9 patients underwent modified Dunn for unstable SCFE with prereduction and postreduction angiography and intraoperative perfusion monitoring via intracranial pressure (ICP) probe. Six patients had no perfusion on preoperative angiography—4 had blood flow restored on postoperative angiography. These patients all showed positive ICP waveforms. Of the 2 patients who had no blood flow on postoperative angiography, 1 had no ICP waveform and developed AVN. However, one patient went on to AVN after both angiography and ICP monitoring indicated restoration of blood flow. No patients with blood flow on the preoperative angiography developed AVN and all these patients showed perfusion with ICP monitoring postreduction. These results suggest that ICP monitoring is a useful method for monitoring epiphyseal perfusion postcapital realignment and may offer feedback regarding iatrogenic changes in blood flow. However, presence of an ICP waveform did not guarantee AVN would not develop and the results must be interpreted in the context of the small sample size of the case series.

Furthering the evidence for perfusion monitoring, a comparison of intraoperative monitoring by epiphyseal drill hole bleeding vs. ICP monitoring either precapital or postcapital realignment in 29 patients revealed no difference in accuracy as determined by the area under the receiver operating curve for each.[32] Descriptive assessment found bleeding after fixation had excellent (100%) specificity, whereas ICP monitoring before retinacular dissection had good sensitivity (67%) for determining which hips would develop osteonecrosis.[32]

Schrader et al[33] described a novel technique for monitoring perfusion during percutaneous screw insertion by inserting an ICP probe through the cannulated screw. Twenty-six patients were followed; all stable hips and 7/13 unstable hips had blood flow as indicated by a pulsatile waveform after initial pinning in situ. The 6 unstable hips with no waveform initially had pulsatile flow restored after percutaneous capsular decompression. At mean 1.9-year follow-up no cases of osteonecrosis were reported. The objective data on perfusion provided by this novel technique may aid intraoperative decision making during in situ fixation of unstable slips and may allow for purposeful closed reduction maneuvers to be performed in a safer manner.

The modified Dunn procedure remains a controversial treatment option for unstable or severe SCFE. The Bernese group has reported success with the modified Dunn with an AVN rate of only 2% overall,[34] and recently presented 10-year follow-up of 42 patients with cumulative survivorship of 93%. In contrast, 2 recent studies from the United States highlighted the risks associated with this

procedure including iatrogenic hip instability.[35,36] Upasani et al[36] found a 4% incidence of anterolateral hip instability after modified Dunn in a multicenter review of 406 hips, with 14/17 patients with instability developing AVN. Davis et al[35] reviewed a cohort of 17 stable slips and found 3 that developed hip instability after modified Dunn, all of which developed AVN. The overall rate of AVN in this stable slip cohort treated by modified Dunn was significantly higher (29.3%) than a previously reviewed cohort of 31 unstable slips (6%).[37] While conclusions regarding the cause of AVN in patients with iatrogenic hip instability after modified Dunn is not possible based on these retrospective reports, the morbidity seen with instability warrants further review.

Few comparative studies of modified Dunn versus in situ pinning are found in the literature. Recent short-term results comparing these 2 procedures in 30 stable slips found a similar rate of complications, including 1 case of AVN in the minimum 1-year follow-up period in each group. However, the modified Dunn was superior in terms of radiographic and clinical outcome scores with a lower risk of reoperation.[38] Which technique is superior, and for what magnitude and classification of slips, is still unknown as SCFE treatment continues to evolve and results vary. Increased sample sizes and scientific rigor through multicenter, comparative collaborations may help elucidate evidence-based treatment algorithms moving forward.

## Infection

Hip infections and those of the surrounding pelvis and femoral region in the pediatric population continue to be important areas of current research. The most common community acquired microorganism in pediatric septic arthritis continues to be methicillin sensitive *Staphylococcus aureus*, while resistant gram-negative bacilli including *Escherichia coli* and *Klebsiella* are the predominant pathogens causing hospital acquired joints infections.[39]

Several recent studies have examined the relationship between septic arthritis and coexisting osteomyelitis.[40,41] A recent study reviewed the incidence of osteomyelitis in patients with a clinical suspicion for septic arthritis of the hip and offered risk factors for predicting the presence of periarticular infection. In their series of 71 patients with 3 or 4 positive Kocher criteria, 22.5% (n = 16) had a diagnosis of septic arthritis and 47.9% (n = 34) had a diagnosis of osteomyelitis. When a hip effusion was identified on ultrasound, 18.9% (7/37) had isolated septic arthritis, 18.9% (7/37) had isolated osteomyelitis, and 24.3% had combined septic arthritis and underlying osteomyelitis.[42] Of those patients with osteomyelitis, 56.4% occurred in the pelvis while 20.5% of cases were found in the proximal femur. The authors suggest that MRI should be strongly considered during the initial work-up of any patient with presumed septic arthritis because of the high rate of coexisting osteomyelitis. Another study, however, found that ordering advanced imaging on a case-by-case basis (based on an individual patient's clinical response after surgical drainage of septic hip arthritis) did not compromise the treatment course.[43] The role of femoral aspiration in treatment of septic arthritis is controversial, and although a recent study found it did not improve microorganism identification, it did aid in the diagnosis of concurrent osteomyelitis when treating septic arthritis especially with false negative MRI.[44]

Septic hip arthritis traditionally is treated by surgical drainage by emergent open arthrotomy and lavage.[44] Recent studies have suggested that hip arthroscopy or repeat hip aspirations (RHA) may have a role. One study showed favorable results from repeated aspirations in a series of 42 patients: 33 patients ages 6 months to 16 years old responded to RHA while 9 patients ages 7 months to 13.7 years required surgical drainage. There was no long term morbidity observed for any child in that study with no evidence of AVN of the femoral head. However, the authors suggested that age older than 10 years may be a cutoff for attempting RHAs; older children had a 57% failure rate to serial aspiration and required formal open arthrotomy versus 14% for those younger than 10 years of age.[44] With regards to using arthroscopy for septic arthritis of the hip in children, one group reported their series of 12 patients ages 19 months to 12 years. Two patients required repeat arthroscopy and two showed radiographic changes of AVN at follow-up.[45]

## CONCLUSIONS

DDH, LCPD, SCFE, and infections about the hip continue to be important topics in pediatric orthopaedics and the areas of important research. In DDH, recent studies have focused on the indications and success rates for PH treatment as well as the risk factors for developing osteonecrosis following closed or open reduction. Over the past few years, research in the area of LCPD has focused on the role and prognostic importance of perfusion MRI for early stage disease and the longer-term results of various forms of containment treatment. Intraoperative monitoring of femoral head perfusion has been an important area of research in SCFE as well as its implications for surgical treatment. Finally, several recent studies have explored the risk factors for coexisting osteomyelitis in the setting of septic arthritis and the potential role for MRI during the early diagnostic work-up for this condition.

## REFERENCES

1. Lee J, Spinnazzola RM, Kohn N, et al. Sonographic screening for developmental dysplasia of the hip in preterm breech infants: do current guidelines address the specific needs of premature infants? *J Perinatol*. 2016;36:552–556.
2. Ramo BA, De La Rocha A, Sucato DJ, et al. A new radiographic classification system for developmental hip dysplasia is reliable and predictive of successful closed reduction and late pelvic osteotomy. *J Pediatr Orthop*. 2018;38:16–21.
3. Miao M, Cai H, Hu L, et al. Retrospective observational study comparing the International Hip Dysplasia Institute classification with the Tonnis classification of developmental dysplasia of the hip. *Medicine (Baltimore)*. 2017;96:e5902.
4. Upasani VV, Bomar JD, Matheny TH, et al. Evaluation of brace treatment for infant hip dislocation in a prospective cohort: defining the success rate and variables associated with failure. *J Bone Joint Surg Am*. 2016;98:1215–1221.
5. Hines AC, Neal DC, Beckwith T, et al. A comparison of pavlik harness treatment regimens for dislocated but reducible (Ortolani+)

hips in infantile developmental dysplasia of the hip. *J Pediatr Orthop*. 2017. [Epub ahead of print].
6. Larson JE, Patel AR, Weatherford B, et al. Timing of Pavlik harness initiation: can we wait? *J Pediatr Orthop*. 2017. [Epub ahead of print].
7. Omeroglu H, Kose N, Akceylan A. Success of Pavlik harness treatment decreases in patients >/= 4 months and in ultrasonographically dislocated hips in developmental dysplasia of the hip. *Clin Orthop Relat Res*. 2016;474:1146–1152.
8. Novais EN, Kestel LA, Carry PM, et al. Higher pavlik harness treatment failure is seen in graf type IV Ortolani-positive hips in males. *Clin Orthop Relat Res*. 2016;474:1847–1854.
9. Sankar WN, Gornitzky AL, Clarke NM, et al. Closed reduction for developmental dysplasia of the hip: early-term results from a prospective, multicenter cohort. *J Pediatr Orthop*. 2016. [Epub ahead of print].
10. Schur MD, Lee C, Arkader A, et al. Risk factors for avascular necrosis after closed reduction for developmental dysplasia of the hip. *J Child Orthop*. 2016;10:185–192.
11. Bradley CS, Perry DC, Wedge JH, et al. Avascular necrosis following closed reduction for treatment of developmental dysplasia of the hip: a systematic review. *J Child Orthop*. 2016;10:627–632.
12. Chen C, Doyle S, Green D, et al. Presence of the ossific nucleus and risk of osteonecrosis in the treatment of developmental dysplasia of the hip: a meta-analysis of cohort and case-control studies. *J Bone Joint Surg Am*. 2017;99:760–767.
13. Niziol R, Elvey M, Protopapa E, et al. Association between the ossific nucleus and osteonecrosis in treating developmental dysplasia of the Hip: updated meta-analysis. *BMC Musculoskelet Disord*. 2017;18:165.
14. Gardner RO, Bradley CS, Sharma OP, et al. Long-term outcome following medial open reduction in developmental dysplasia of the hip: a retrospective cohort study. *J Child Orthop*. 2016;10:179–184.
15. Yilmaz S, Akashin E, Ersoz M, et al. The fate of iliopsoas muscle in the long-term follow-up after open reduction of developmental dysplasia of the hip by medial approach. part 1: mri evaluation. *J Pediatr Orthop*. 2017;37:392–397.
16. Yilmaz S, Aksahin E, Duran S, et al. The fate of the iliopsoas muscle in long-term follow-up after open reduction with a medial approach in developmental dysplasia of the hip. part 2: isokinetic muscle strength evaluation. *J Pediatr Orthop*. 2017;37:398–402.
17. Kim HK, Wiesman KD, Kulkarni V, et al. Perfusion MRI in early stage of Legg-Calve-Perthes disease to predict lateral pillar involvement: a preliminary study. *J Bone Joint Surg Am*. 2014;96:1152–1160.
18. Kim HK, Burgess J, Thoveson A, et al. Assessment of femoral head revascularization in Legg-Calve-Perthes disease using serial perfusion MRI. *J Bone Joint Surg Am*. 2016;98:1897–1904.
19. Conway JJ. A scintigraphic classification of Legg-Calve-Perthes Disease. *Semin Nucl Med*. 1993;23:274–295.
20. Tsao AK, Dias LS, Conway JJ, et al. The prognostic value and significance of serial bone scintigraphy in Legg-Calve-Perthes disease. *J Pediatr Orthop*. 1997;17:230–239.
21. Kamiya N, Yamaguchi R, Adapala NS, et al. Legg-Calve-Perthes disease produces chronic hip synovitis and elevation of interleukin-6 in the synovial fluid. *J Bone Miner Res*. 2015;30:1009–1013.
22. Shohat N, Copeliovitch L, Smorgick Y, et al. The long-term outcome after varus derotational osteotomy for Legg-Calve-Perthes Disease: a mean follow-up of 42 years. *J Bone Joint Surg Am*. 2016;98:1277–1285.
23. Mosow N, Vettorazzi E, Breyer S, et al. Outcome after combined pelvic and femoral osteotomies in patients with Legg-Calve-Perthes disease. *J Bone Joint Surg Am*. 2017;99:207–213.
24. Nakamura J, Kamegaya M, Saisu T, et al. Outcome of patients with Legg-Calve-Perthes onset before 6 years of age. *J Pediatr Orthop*. 2015;35:144–150.
25. Poussa M, Schlenzka D, Yrjonen T. Body mass index and slipped capital femoral epiphysis. *J Pediatr Orthop B*. 2003;12:369–371.
26. Manoff EM, Banffy MB, Winell JJ. Relationship between body mass index and slipped capital femoral epiphysis. *J Pediatr Orthop*. 2005;25:744–746.
27. Bhatia NN, Pirpiris M, Otsuka NY. Body mass index in patients with slipped capital femoral epiphysis. *J Pediatr Orthop*. 2006;26:197–199.
28. Herngren B, Stenmarker M, Vavruch L, et al. Slipped capital femoral epiphysis: a population-based study. *BMC Musculoskelet Disord*. 2017;18:304.
29. Perry DC, Metcalfe D, Costa ML, et al. A nationwide cohort study of slipped capital femoral epiphysis. *Arch Dis Child*. 2017;102:1132–1136.
30. Halverson SJ, Warhoover T, Mencio GA, et al. Leptin elevation as a risk factor for slipped capital femoral epiphysis independent of obesity status. *J Bone Joint Surg Am*. 2017;99:865–872.
31. Jackson JB III, Frick SL, Brighton BK, et al. Restoration of blood flow to the proximal femoral epiphysis in unstable slipped capital femoral epiphysis by modified Dunn procedure: a preliminary angiographic and intracranial pressure monitoring study. *J Pediatr Orthop*. 2018;38:94–99.
32. Novais EN, Sink EL, Kestel LA, et al. Is assessment of femoral head perfusion during modified Dunn for unstable slipped capital femoral epiphysis an accurate indicator of osteonecrosis? *Clin Orthop Relat Res*. 2016;474:1837–1844.
33. Schrader T, Jones CR, Kaufman AM, et al. Intraoperative monitoring of epiphyseal perfusion in slipped capital femoral epiphysis. *J Bone Joint Surg Am*. 2016;98:1030–1040.
34. Tannast M, Jost LM, Lerch TD, et al. The modified Dunn procedure for slipped capital femoral epiphysis: the Bernese experience. *J Child Orthop*. 2017;11:138–146.
35. Davis RL II, Samora WP III, Persinger F, et al. Treatment of unstable versus stable slipped capital femoral epiphysis using the modified Dunn procedure. *J Pediatr Orthop*. 2017. [Epub ahead of print].
36. Upasani VV, Birke O, Klingele KE, et al. Iatrogenic hip instability is a devastating complication after the modified Dunn procedure for severe slipped capital femoral epiphysis. *Clin Orthop Relat Res*. 2017;475:1229–1235.
37. Persinger F, Davis RL II, Samora WP, et al. Treatment of unstable slipped capital epiphysis via the modified dunn procedure. *J Pediatr Orthop*. 2018;38:3–8.
38. Novais EN, Hill MK, Carry PM, et al. Modified Dunn procedure is superior to in situ pinning for short-term clinical and radiographic improvement in severe stable SCFE. *Clin Orthop Relat Res*. 2015;473:2108–2117.
39. Motwani G, Mehta R, Aroojis A, et al. Current trends of microorganisms and their sensitivity pattern in paediatric septic arthritis: a prospective study from tertiary care level hospital. *J Clin Orthop Trauma*. 2017;8:89–92.
40. Rosenfield S, Bernstein D, Daram S, et al. Predicting the presence of adjacent infections in septic arthritis in children. *J Pediatr Orthop*. 2016;36:70–74.
41. Schlung JE, Bastrom TP, Roocroft JH, et al. Femoral neck aspiration aids in the diagnosis of osteomyelitis in children with septic hip. *J Pediatr Orthop*. 2016. Doi: 10.1097/BPO.0000000000000868. [Epub ahead of print].
42. Nguyen A, Kan JH, Bisset G, et al. Kocher criteria revisited in the era of MRI: How often does the Kocher criteria identify underlying osteomyelitis? *J Pediatr Orthop*. 2017;37:e114–e119.
43. Refakis CA, Arkader A, Baldwin KD, et al. Predicting periarticular infection in children with septic arthritis of the hip: regionally derived criteria may not apply to population. *J Pediatr Orthop*. 2017. Doi: 10.1097/BPO.0000000000000934. [Epub ahead of print].
44. Weigl DM, Becker T, Mercado E, et al. Percutaneous aspiration and irrigation technique for the treatment of pediatric septic hip: effectiveness and predictive parameters. *J Pediatr Orthop B*. 2016;25:514–519.
45. Sanpera I, Raluy-Collado D, Sanpera-Iglesias J. Arthrosopy for hip septic arthritis in children. *Orthop Traumatol Surg Res*. 2016;102:87–89.