Indications for hip arthroscopy in pediatric patients: a systematic review

Moayd Abdullah H. Awad1, Arpun K. Bajwa2, Erin Slaunwhite3, Karl J. Logan1 and Ivan H. Wong1*

1Division of Orthopaedic Surgery, Department of Surgery, Faculty of Medicine, Dalhousie University, 4554-1796 Summer Street, Halifax, Nova Scotia B3H 3A7 Canada,
2Sports Medicine, College of Medicine, University of Illinois, 820 South Wood Street, Suite 100 CSN M/C 675 Chicago, IL 60612, USA and
3Emergency Medicine Resident, Emergency Medicine, Queens University, 76 Stuart Street, Kingston ON K7L 2V7, Canada.
*Correspondence to: I. Wong. E-mail: iw@drivanwong.com
Submitted 3 July 2019; revised version accepted 5 October 2019

ABSTRACT

The purpose of this study was to evaluate the current available literature on hip arthroscopy and determine the clinical indications in the pediatric patient population (age ≤ 18). In accordance with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), a comprehensive literature search was performed on the 23 October 2018 using PubMed, Cochrane Library, Embase and e-books to identify research surrounding the use of hip arthroscopy in the pediatrics. Exclusion criteria were studies that described joints other than the hip, animal studies, systematic reviews, open procedures and those that reported solely on patients aged 19-year-old and older. From 232 studies, 57 were reviewed in detail; 17 articles were removed as their indication fell into a category of ‘diagnostic hip arthroscopy for pain’ or no clear separation between the data on the adult and pediatric population could be made in a full text review of the paper. Eleven categories were identified as indications for hip arthroscopy in the pediatric population. At best a Grade C recommendation can be made to support the use of hip arthroscopy in the pediatric population. Our results support our hypothesis. Despite the exponential increase in hip arthroscopy over the last decade, limited evidence exists in support of its use in the pediatric (≤ 18) population. Our findings support the need for further research in delineating the indications for its use, as clearly arthroscopy may be advantageous in many situations, particularly in light of the alternatives.

INTRODUCTION

Over the last decade the clinical indications and utility of hip arthroscopy have increased. Unfortunately, the scientific evidence to support this practice is inadequate, particularly in children. Arthroscopy can provide several benefits and fewer complications compared to open hip surgery. These benefits include smaller incisions, faster recovery times, quicker return to activities, a decreased risk for hip dislocation and avascular necrosis (AVN) of the femoral head [1]. Current indications for hip arthroscopy in the adult literature include labral tears, intra-articular loose body, femoro-acetabular impingement (FAI), ruptured ligamentum teres, chondral injury and degeneration, iliopsoas and iliotibial band (ITB) contracture, snapping hip, arthritis, adhesive capsulitis, instability, gluteus medius and minimus tendinopathy and tear, hamstring tear and synovial disease [2]. The indications are not well defined in the pediatric population.

The purpose of this study was to evaluate the current available literature on hip arthroscopy and determine the clinical indications in the pediatric patient population (age ≤ 18). Our hypothesis was that there was limited evidence in the literature to support the use of hip arthroscopy in the pediatric population.

MATERIALS AND METHODS

A comprehensive literature search was performed on the 23 October 2018 using PubMed, Cochrane Library, Embase and e-books to identify research surrounding the
The use of hip arthroscopy in the pediatric patient population. The electronic search strategy used was (Hip OR Hip Injuries OR Osteoarthritis, Hip OR Hip Prosthesis OR Hip Joint OR Hip Fractures OR Hip Dislocation, Congenital OR Hip Dislocation OR Hip Contracture OR Hip Dysplasia, Beukes Type [Supplementary Concept] AND Arthroscopy AND humans AND English[lang] AND infant OR child OR adolescent OR infant OR adolescent OR child, preschool OR child). The inclusion criteria identified studies that reported on hip arthroscopy performed in children, adolescents or teenagers 18 years of age and younger. Exclusion criteria were studies that described joints other than the hip, animal studies, systematic reviews, open procedures and those that reported solely on patients 19 years of age and older. Two researchers reviewed the studies independently, first by title review, then abstract, and finally the articles. After each round of review, the researchers met to discuss and resolved any disagreement. In those papers that reported on adults and children, we extracted the relevant information if it had been explicitly provided within the article. Figure 1 demonstrates the review process, indicating the number of articles included and excluded at different phases of the review process. All articles and their level of evidence (LOE) were then summarized to assign a Grade of Recommendation for each indication for hip

**Fig. 1.** An illustration of the systematic review process generating the 40 crucial articles included in the review, indicating the numbers of exclusions throughout the review phases.
arthroscopy in the pediatric population, A-B-C or I (Tables I–III) [3].

RESULTS
A total of 57 articles were reviewed in detail. A consensus was made to remove 17 articles as their indication fell into a category of ‘diagnostic hip arthroscopy for pain’ or no clear separation between the data on the adult and pediatric population could be made in a full text review of the paper. Eleven categories were identified as indications for hip arthroscopy in the pediatric population: (i) Failed Closed Reduction of the Hip in Developmental Dysplasia of the Hip (DDH), (ii) Sequelae of DDH, (iii) Septic Arthritis, (iv) Traumatic Hip Dislocation, (v) Legg-Calvé Perthes disease (LCPD), (vi) FAI/Labral Tear, (vii) Loose Body, (viii) Exostosis, (ix) slipped capital femoral epiphysis (SCFE), (x) Extra-articular pathology and (xi) Juvenile chronic arthritis (JCA). The quality of evidence and the grade of recommendation are summarized in Table II.

Table I. Grade of recommendation

| Grade    | Description                                      |
|----------|--------------------------------------------------|
| A (Good) | Level I studies with consistent findings         |
| B (Fair) | Level II or III studies with consistent findings |
| C (Poor) | Level IV or V studies OR conflicting evidence    |
| Cf       | Majority of studies supports the intervention    |
| Cn       | Majority of studies against the intervention     |
| Ci       | Conflicting studies with no clear majority       |
| I (Insufficient) | Insufficient evidence to make any recommendation |

Table II. Quality of evidence and grade of recommendation (GOR) for hip arthroscopy indications in pediatrics

| Indication                  | n | I    | II   | III  | IV   | V    | GOR |
|-----------------------------|---|------|------|------|------|------|-----|
| Failed closed reduction of the hip in DDH | 6 | 1<sup>8(F)</sup> | 1<sup>8(F)</sup> | 5<sup>4(F), 6(F), 7(A), 8(F), 9(A)</sup> | C<sub>i</sub> |
| FAI/labral tears            | 8 | 1<sup>10(F)</sup> | 1<sup>11(F)</sup> | 4<sup>12(F), 13(F), 16(F), 17(F)</sup> | 2<sup>13(F), 14(F)</sup> | C<sub>f</sub> |
| Sequelae of DDH             | 4 | 2<sup>20(F), 21(F)</sup> | 2<sup>21(F)</sup> | 2<sup>18(F), 19(F)</sup> | C<sub>f</sub> |
| Septic arthritis            | 4 | 4<sup>22(F), 23(F), 24(F), 25(F)</sup> | 2<sup>24(F), 25(F)</sup> | C<sub>f</sub> |
| Traumatic hip dislocation   | 3 | 2<sup>26(F), 27(F)</sup> | 2<sup>27(F)</sup> | 1<sup>28(F)</sup> | C<sub>f</sub> |
| LCPD                        | 5 | 4<sup>29(F), 30(F), 31(F), 33(F)</sup> | 4<sup>31(F)</sup> | 1<sup>32(F)</sup> | C<sub>f</sub> |
| Loose bodies                | 3 | 3<sup>34(F), 35(F), 36(F)</sup> | 3<sup>36(F)</sup> | 1<sup>37(F)</sup> | C<sub>f</sub> |
| Exostosis                   | 1 | 1<sup>38(F)</sup> | 1<sup>38(F)</sup> | 1<sup>38(F)</sup> | I    |
| SCFE                        | 1 | 1<sup>38(F)</sup> | 1<sup>38(F)</sup> | 1<sup>38(F)</sup> | I    |
| Extra-articular pathology   | 4 | 2<sup>40(F), 42(F)</sup> | 2<sup>42(F)</sup> | 2<sup>39(F), 41(F)</sup> | I    |
| JCA                         | 1 | 1<sup>43(F)</sup> | 1<sup>43(F)</sup> | 1<sup>43(F)</sup> | I    |

(F), for; (A), against; C<sub>i</sub>, majority of studies supports the intervention; I, insufficient evidence to make any recommendation.
| Authors                  | Year | LOE | No. of pediatric patients | Average age (years) | Follow-up time (months) |
|-------------------------|------|-----|---------------------------|--------------------|------------------------|
| Failed closed reduction of the hip in DDH |      |     |                           |                    |                        |
| Xu et al.               | 2017 | IV  | 40                         | 1.8                | 71                     |
| Zhao et al.             | 2017 | II  | 8                          | 1.4                | 60                     |
| Öztürk et al.           | 2013 | IV  | 9                          | 1.09               | 47.7                   |
| Eberhardt et al.        | 2012 | IV  | 5                          | 5.8                | 13.2                   |
| Kitano et al.           | 2010 | IV  | 10                         | 1.88               | 64                     |
| McCarthy and MacEwen    | 2007 | IV  | 3                          | 1.17               | 9                      |
| FAI/labral tear         |      |     |                           |                    |                        |
| Ashberg et al.          | 2018 | II  | 157                        | 15.5               | 24                     |
| Byrd et al.             | 2016 | III | 108                        | 16                 | 30                     |
| Philippon et al.        | 2012 | IV  | 60                         | 15                 | 42                     |
| Larson and Stone        | 2011 | V   | 1                          | 18                 | 24                     |
| Sekiya et al.           | 2009 | V   | 1                          | 17                 | 24                     |
| Philippon et al.        | 2008 | IV  | 16                         | 15                 | 24                     |
| McCarthy et al.         | 2003 | IV  | 2                          | 18                 | 18                     |
| Ikeda et al.            | 1988 | IV  | 6                          | 15.2               | NS                     |
| Sequelae of DDH         |      |     |                           |                    |                        |
| Larson et al.           | 2011 | V   | 1                          | 17                 | 18                     |
| Klein et al.            | 2010 | V   | 2                          | 16                 | 36                     |
| Fujii et al.            | 2009 | IV  | 22                         | 16.4               | NS                     |
| Ilizaliturri et al.     | 2005 | IV  | 2                          | 18                 | 18                     |
| Septic arthritis        |      |     |                           |                    |                        |
| Sanpera et al.          | 2015 | IV  | 12                         | 6                  | 24                     |
| Nusem et al.            | 2006 | IV  | 3                          | 15                 | 16                     |
| Chung et al.            | 1993 | IV  | 3                          | 4.42               | NS                     |
| Blitzer                 | 1993 | IV  | 3                          | 12.6               | NS                     |
| Traumatic hip dislocation |    |     |                           |                    |                        |
| Morris et al.           | 2017 | IV  | 7                          | 12.5               | 10                     |
| Philippon et al.        | 2009 | IV  | 5                          | 17                 | NS                     |
| Kashiwagi et al.        | 2001 | V   | 1                          | 10                 | 12                     |

(continued)
subluxated or developed AVN were Tönnis grade four hips pre-operatively (LOE IV).

Zhao et al. [5] reported prospectively on eight patients aged 12–22 months, who failed closed reduction of the hip and then underwent arthroscopic reduction. Concentric reduction was achieved in all patients. The safe zone increased from average of 17.5 pre-operatively to 42.1 post-operatively. Acetabular index was reduced by the average of 18.4 degrees, from 40.3 pre-operatively to 21.9 at final follow-up. The authors reported no significant complications including AVN or subluxation post-operatively (LOE II).

Öztürk et al. [6] conducted a review of nine patients under 18 months of age for which a stable reduction of the hip was not achieved under general anesthetic. Arthroscopy was used for resection of ligamentum teres, incision of the transverse acetabular ligament and removal of the pulvinar (± adductor tenotomy). One patient (11%) developed AVN, two (22%) had residual acetabular dysplasia and one (11%) required a Salter Osteotomy (LOE IV).

Eberhardt et al. [7] reported on five infants (eight hips), mean age 5.8 months, with DDH in whom closed reduction of the hip was attempted but failed and subsequently underwent arthroscopic release of the capsule and resection of the ligamentum teres. Three out of eight hips (38%) developed AVN at a mean follow-up of 13.2 months (LOE IV).

Kitano et al. [8] reported on arthroscopic reduction of dislocated hips after walking age with limboplasty in 10

---

Table III. (continued)

| Authors                | Year | LOE | No. of pediatric patients | Average age (years) | Follow-up time (months) |
|------------------------|------|-----|----------------------------|---------------------|------------------------|
| LCPD                   |      |     |                            |                     |                        |
| Freeman et al.         | 2013 | IV  | 8                          | 15.4                | 24                     |
| Majewski et al.        | 2010 | IV  | 11                         | 13                  | 24                     |
| Roy                    | 2005 | IV  | 9                          | 15                  | 24                     |
| Kuklo et al.           | 1999 | V   | 1                          | 7                   | 5                      |
| Suzuki et al.          | 1994 | IV  | 19                         | 8                   | 0.5                    |
| Loose bodies           |      |     |                            |                     |                        |
| Nepple et al.          | 2011 | V   | 1                          | 12                  | 24                     |
| Kusma et al.           | 2004 | V   | 1                          | 18                  | 3                      |
| Byrd                   | 1996 | IV  | 1                          | 17                  | 33                     |
| Exostosis              |      |     |                            |                     |                        |
| Bonnomet et al.        | 2001 | V   | 2                          | 10                  | 36                     |
| SCFE                   |      |     |                            |                     |                        |
| Leunig et al.          | 2010 | IV  | 3                          | 12.6                | 24                     |
| Extra-articular pathology |    |     |                            |                     |                        |
| Lindner et al.         | 2014 | V   | 1                          | 16                  | 3                      |
| Zini et al.            | 2013 | IV  | 4                          | 17.8                | 40.8                   |
| Kunac et al.           | 2012 | V   | 2                          | 14.5                | 24                     |
| Anderson and Knee      | 2008 | IV  | 5                          | 16.6                | 12                     |
| JCA                    |      |     |                            |                     |                        |
| Holgersson et al.      | 1981 | IV  | 13                         | 13.8                | NS                     |
patients. A 3D CT arthrography subtraction technique was used to assess hips pre-operatively for intra-capsular blocks to reduction. At 5.4 years there were no cases of moderate or severe AVN and two (20%) cases of mild AVN. Two (20%) hips had additional surgery within the study period (LOE IV).

McCarthy et al. [9] used hip arthroscopy as an adjunct in failed closed reduction of the hip for DDH. One of three patients developed AVN (33%) by follow-up of 9 months (LOE IV).

FAI/labral tear

Eight articles: one Level II, one Level III and six Levels IV and V

Ashberg et al. [10] reported patient reported outcome scores (PROs) of 157 patients undergoing hip arthroscopy for labral tears to compare early versus late treatment. All patients were 18 years old and under ranging from 13 to 18 at the time of surgery. Follow-up for minimum of 2 years. All other hips were excluded. Cohort divided patients into two groups acute and chronic. All patients had improved PROs post-operatively (Modified Haris Hip Score (mHHS) from 64.8 to 84.1; non-arthritic hip score from 65.9 to 88.4 and Hip Outcome Score (HOS)-sport specific subclasses (SSS) from 46.8 to 79.6) \( P < 0.001 \). No significant difference between early and late groups except for Visual analog scale (VAS) for pain which improved significantly with the chronic group. VAS improved for both groups from 5.8 pre-operative to 1.9 post-operatively \( (P > 0.001) \). Higher rate of reoperation was also noted in the acute group with similar improvement in the PROs after the second surgery (LOE II).

Byrd et al. [11] reported outcomes of 122 consecutive hips of adolescent patients aged 18 and younger compared to a same number of control group of adults who underwent the same procedure for similar diagnosis of FAI. A mHHSs showed significant improvement of 25.4 in the study group compared with 22.2 in the control at the end of follow-up. Four patients from the study group required revision arthroscopy and 1 required peri-acetabular osteotomy for acetabular dysplasia. No major complications were identified in both groups (LOE III).

Philippon et al. [12] evaluated the outcomes of hip arthroscopy for 60 pediatric patients aged 16 and younger, treated for FAI. They excluded any patient who had previous surgery or had a center-edge angle of 25 degrees or below. At mean follow-up of 3.5 years their mHHS improved from a mean of 57 to a mean of 91. Eight patients (all girls) required a revision surgery for capsulolabral adhesions (LOE IV).

Larson et al. [13] presented two athletes (one within our age criteria) with acetabular rim fractures who underwent arthroscopic reduction and fixation. The patient underwent internal fixation, rim resection, labral repair and osteochondroplasty of the CAM. He returned to wrestling at 4 months and at 2 years had improvements in his mHHS from 81.2 to 97.8, short form 12 from 97 to 98 and VAS pain score from 3.1 to 0.9 (LOE V).

Sekiya et al. [14] presented a 17-year-old boy with bilateral hip pain and signs of impingement. Examination revealed positive FADIR (flexion, adduction, internal rotation) and FABER (flexion, abduction, external rotation) tests with diminished passive hip range of motion (ROM). MR-arthrogram (MRA) demonstrated a labral tear. During his bilateral staged hip arthroscopy, he underwent osteoplasty, chondroplasty, and capsular plication. In the right hip a labral repair and psoas lengthening were also undertaken. Two-years post-operatively his mHHS was 96 (no pre-operative score provided) (LOE V).

Philippon et al. [15] reported on 17 patients with FAI who failed conservative management. After radiographs and MRI, patients underwent femoral head neck osteoplasty with pincer resection and any labral pathology was also addressed. At 24-month follow-up, mHHS scores rose from 55 to 90, HOS sport increased from 33 to 89 and HOS activities of daily living increased from 58 to 94. All returned to their desired sport (LOE IV).

McCarthy et al. [16] studied 10 patients with two patients under 20 years. Both were professional hockey players with mechanical hip symptoms that failed conservative measures. One player had a torn anterior labrum and loose bodies with ‘excellent’ outcomes 6 years post-arthroscopy. The second patient underwent bilateral hip arthroscopy for anterior labral tears. At 4-month follow-up he had a hip flexor strain with subsequent MRI negative for labral tear. All players returned to sport and no peri-operative complications occurred (LOE IV).

Ikeda et al. [17] reported on six patients who underwent hip arthroscopy with a mean age of 15 years as the basis to discuss the etiology, diagnosis and treatment of a torn labrum. One patient with a history of DDH, others all had normal X-rays with a clinical assessment consistent with labral tear. The authors commented that repeat arthroscopy showed disappearance of vascular changes observed on initial arthroscopy (LOE IV).

Sequelae of DDH

Four articles: all Levels IV and V

Larson et al. [18], reported on three patients of which only one patient met our age inclusion criteria. A 17-year-old
male hockey player with DDH and previous pelvic osteotomy presented with symptoms of groin pain and limited hip flexion. His lateral center-edge angle was 25° with a prominent antero-inferior iliac spine (AIIS). An AIIS decompression was conducted with no complications. Harris Hip Score (HHS) increased from 74 pre-operatively to 100 post-operatively and VAS of 4.85–0 at 1.5 years post-operatively (LOE V).

Klein et al. [19] reported on three patients, two who were <10 years of age, who had Pemberton Osteotomies for DDH as children and presented with hip symptoms as young adults. The first patient was a 16-month-old infant with a dislocated hip placed in traction followed by open reduction. At age 5 she had a Pemberton Osteotomy and remained asymptomatic for 10 years then developed hip pain. Hip arthroscopy was performed, after a negative MRA, and an unstable portion of the labrum was resected. Her HHS improved from 52 to 81 at 3 years post-arthroscopy. The second patient, a 6-year-old, with bilateral DDH underwent open reduction, Pemberton Osteotomies, femoral shortening osteotomies, adductor releases and distal ITB releases. Subsequently she developed snapping hip with femoral cystic changes and underwent curettage and bone grafting with a blade plate at age 14. Her symptoms did not improve and she underwent a hip arthroscopy with labral debridement and hardware removal increasing her HHS from 59 to 92 at 3 years post-operatively. (LOE V).

Fuji et al. [20] presented 23 hips that underwent hip arthroscopy at the time of pelvic osteotomy with acetabular dysplasia secondary to DDH. The average age of the patients was 16.4 years. The indication for arthroscopy was for assessment of the articular cartilage in patients younger than 20 with symptomatic DDH. Fourteen hips in the pre-arthritic stage had cartilage degeneration. Lesions were more frequent in the acetabulum than femoral head. Sixty one percent of acetabular lesions were in the antero-superior area. Labral tears were seen in 77.8% of the hips in the pre-arthritic stage. A ‘second look’ arthroscopy was conducted at 18.9 months post-osteotomy, although the authors did not give clear indications for this secondary procedure (LOE IV).

Ilizaliturri et al. [21] reported on hip arthroscopy in symptomatic patients with previous acetabular osteotomy for DDH. Two out of seven (mean age 18 years) of their patients met our age criteria. Both patients presented with mechanical hip symptoms at an average of 7.5 years post-osteotomy. Acetabular chondrolabral degeneration was identified arthroscopically and treated with labral debridement and chondral drilling. The Western Ontario and McMaster Universities Osteoarthritis Index scores averaged 30 pre-operatively and 10 at 1.5 years post-operatively (LOE IV).

Septic arthritis

Four articles: all Level IV
Sanpera et al. [22] reported 12 patients with septic arthritis of the hip with a median age of 6 years. All patients were treated using arthroscopic drainage. All patients responded well to the procedure with marked clinical improvement within the first 36 h, with the exception of three patients. One patient required 4 days for fever remission and two patients underwent repeat arthroscopy and lavage for persistent hip fever. At 1 year, all patients had an excellent clinical result (HHS >90). Only one patient had poor results (HHS > 62) due to late presentation and therefore drainage. This caused AVN or a growth arrest that resulted in a deformity requiring a posterior corrective osteotomy (LOE IV).

Nusem et al. [23] reported on six patients (three of which met our age inclusion criteria) who underwent arthroscopic-assisted lavage and debridement of a septic hip with no major complications at 4-year follow-up (LOE IV).

Chung et al. [24] assessed nine hips that underwent arthroscopic lavage. Successful treatment was achieved in all patients with no complications, although the follow-up period was not disclosed (LOE IV).

Blitzer [25] examined three patients with a mean age of 12.6 years who underwent hip arthroscopy for septic arthritis. All patients had a fluoroscopic aspiration followed by arthroscopy with lavage using 3 l of ringer’s lactate and a drain for 72 h post-operatively. With a delay in presentation and concomitant acetabular rim fracture, one patient developed arthritis and required a hip arthrodesis (LOE IV).

Traumatic hip dislocation

Three articles: all Levels IV and V
Morris et al. [26] reported on seven patients aged 8–17 who presented with a traumatic posterior fracture dislocation of the hip and whose treatment was assisted with hip arthroscopy. Five patients had open growth plates. Six patients had intra-articular fragments and five had an incongruent closed reduction. Average follow-up was 10 months. Only two patients completed HOSs and scored 97.4 and 98.5 out of 100 for activates and daily living, and 100 and 97.2 for sports. One patient had occasional discomfort. No post-operative AVN or instability was reported (LOE IV).

Philippon et al. [27] reported on 14 professional athletes with hip pain (5 patients aged 19 or under) who underwent hip arthroscopy at an average of 123.2 days following traumatic hip dislocation. In total 5 of 14 patients had chondral defects, 4 had labral tears, 4 had ligamentum
teres tears, 3 demonstrated CAM lesions, 3 had pincer lesions, 1 had intracapsular adhesions and 1 had a capsular tear. All returned to full competitive sport after hip arthroscopy (LOE IV).

Kashiwagi et al. [28] published a case report of a 10-year-old girl with a traumatic hip dislocation and subsequent impingement of the avulsed ligamentum teres. She underwent arthroscopic excision of the ligamentum teres and was asymptomatic at 1-year follow-up (LOE V).

**Legg-Calve Perthes disease**

Freeeman et al. [29] studied 23 hips of which eight that met our age criteria. They were followed prospectively following arthroscopy for sequelae of LCPD. The indication for surgery was recalcitrant hip pain with evidence of intra-articular pathology including loose bodies, labral tears and cartilage lesions. At 2 years of follow-up the average mHHS increased from 55.88 pre-operatively to 85.25 post-operatively. No complications were reported. One patient reported no change in symptoms and went on to receive a second arthroscopy (LOE IV).

Majewski et al. [30] reviewed 11 patients, mean age 13 years, who failed non-operative management of LCPD with increasing hip stiffness. The purpose for arthroscopy was hydraulic mobilization of the hip joint with debridement. At 1-year follow-up increased ROM was maintained and no complications were reported (LOE IV).

Roy [31] assessed the use of hip arthroscopy to evaluate and treat hip pain in nine patients who had a remote diagnosis of LCPD. All patients had previous surgery consisting of five innominate osteotomies with shelf acetabuloplasty, one shelf acetabuloplasty, one medial release with subsequent shelf acetabuloplasty and a greater trochanteric epiphysiodesis. At arthroscopy, four patients had ligamentum teres tears, three had femoral head OCDs, three had femoral head abnormalities (cartilage flap tear, mild chondromalacia), two with labral tears and two patients had synovitis. Seven of these patients improved following their arthroscopy, two underwent repeat arthroscopy (indication unclear) and one underwent a total hip replacement at 3-year follow-up (LOE IV).

Kuklo et al. [32] presented a case report of a 7-year-old boy with LCPD that had a prominent superficial island of epiphyseal ossification in his right femoral head. MRI and CT scan were conducted pre-operatively followed by arthroscopic debridement of the bone island to decrease its prominence and improve congruity. The patient demonstrated ROM improvement with no pain at 5-month follow-up (LOE V).

Suzuki et al. [33] reported on arthroscopy in 19 children with Perthes disease. The indication for operative intervention was: (i) persisting hip pain or limited motion after 4 weeks of traction, (ii) recurrence of hip pain during or after treatment and (iii) a diagnostic arthroscopy. At the time of arthroscopy, more than a liter of fluid was irrigated through the joint and a punch biopsy of the synovium was taken. Although follow-up time was 2 weeks, both pain and ROM improved post-operatively. The authors visualized hypertrophy of the synovium and increased vascularity of the labrum intra-operatively. They postulated that this hypertrophy contributes to lateral subluxation of the femoral head seen in Perthes (LOE IV).

**Loose bodies**

Nepple et al. [34] reported on a 12-year-boy who sustained a hip injury 2 months prior while water skiing. He remained unable to weight bear at his 4-week follow-up visit and a subsequent MRI revealed a fracture of the posterior wall of the acetabulum with a ligamentum teres rupture and a fracture of the non-weight bearing portion of femoral head. He was initially managed non-operatively. A repeat MRI, CT scan and radiographs 4 weeks later revealed an incongruous reduction and incarcerated osteochondral fragment. A hip arthroscopy revealed a large postero-superior labral/acetabular rim chondral avulsion fragment trapped within the acetabular fossa with fibrous scar tissue and femoral head abrasions. Definitive treatment included an open procedure (surgical hip dislocation with trochanteric flip osteotomy) with reduction and fixation of the acetabular rim. Two years post-operatively he had an HHS of 100 with full symmetric ROM and no significant adverse radiographic changes. He returned to competitive water skiing (LOE V).

Kusma et al. [35] describes an 18-year-old female horseback rider with an avulsion fracture of the ligamentum teres causing hip pain and locking for 2 years. Radiographs and a CT scan demonstrated loose bodies within the joint. At 3-month follow-up after arthroscopic loose body removal and joint debridement she was symptom free (LOE V).

Byrd et al. [36] reported on three patients, one within our age criteria. A 17-year-old boy, 2 years following non-operative treatment for an acetabular fracture remained symptomatic and was found to have loose bodies in his hip joint on plain radiograph and CT arthrogram. He underwent hip arthroscopy with removal of loose bodies and marked improvement in his symptoms at 33-month follow-up (LOE IV).
Exostosis

One Level V article
Bonnomet et al. [37] report an 11-year-old boy and 9-year-old girl with hereditary multiple exostosis who underwent hip arthroscopy for the debridement of osteochondromas secondary to pain, limp and stiffness. Imaging demonstrated osteochondroma and subluxation of the hip. After arthroscopic excision of the lesions they were both symptom free at 3 years of follow-up (LOE V).

Slipped capital femoral epiphysis

One Level IV article
Leunig et al. [38] reported on three patients 11–15 years (BMI 22–31 kg/m²), with 2–12 weeks of hip pain and limp. Plain radiographs demonstrated mild (slip angle < 30 degrees) stable SCFE. All had signs of impingement at presentation and underwent in situ fixation followed by hip arthroscopy with head/neck osteoplasty for restoration of offset. An average correction of 37 degrees in pre- and post-operative alpha angle was seen, as well as an average of 5.2 mm difference in offset. The average post-operative UCLA activity scale score was 8.6. At their most recent follow-up (6–23 months post-operatively) all patients were pain free and had returned to full activities without complication (LOE IV).

Extra-articular pathology

Four articles: all Levels IV and V
Linder et al. [39] published their arthroscopic repair of a chronic incomplete proximal hamstrings avulsion in a cheerleader 18 months after injury. Two anchors were used for tendon re-attachment with hamstrings bursectomy and sciatic neurolysis. At 3 months she was back to baseline function with no complications (LOE V).

Zini et al. [40] report on four patients with snapping ITB syndrome that met our age inclusion criteria. Diagnosis was confirmed with US although radiographs and MRI were also completed. The ITB was released arthroscopically and at 40-month follow-up the Tegener score did not change from pre- to post-operative; VAS went from five pre- to zero post-operatively and post-operative HHS was 100 (LOE IV).

Kunac et al. [41] presented two cases with a mean age of 14.5 years who failed conservative treatment of their ITB snapping hip syndrome. With normal radiographs and MRA, arthroscopic incision of the IT band and bursectomy was performed. At 21-month follow-up there was no snapping or pain (LOE V).

Anderson et al. [42] reported on 15 patients with painful snapping psoas tendons, of which five met our age criteria. Patients were assessed with MRA and were categorized according to the pain relief they experienced after a local anesthetic injection into the psoas sheath under ultrasound guidance. Patients in whom the injection was successful went on to arthroscopic release of the tendon. All patients had relief with return to full sport and improvements in their HHS from 32 pre- to 97.6 post-operatively (LOE IV).

Juvenile chronic arthritis

One Level IV article
Holgersson et al. [43] reported on thirteen patients in our age criteria with JCA whose hip pain was not relieved by physiotherapy and anti-inflammatory medication. All patients had pre-operative radiographs and underwent arthroscopic assessment of their joint and synovial biopsy. This was followed by an open antero-lateral approach for synovectomy. The authors reported no complications (LOE IV).

DISCUSSION

Failed closed reduction of the hip in DDH
Grade C recommendation: one Level II and five Level IV studies
Opinion: indeterminate
The reviewed studies contain few patients of different ages and variable indications for hip arthroscopy. From this heterogenous pool of patients it is difficult to draw any firm conclusions or give anything other than an indeterminate recommendation. It does appear however that hip arthroscopy can be a useful tool in obtaining reduction of the subluxed or dislocated hip with similar AVN rates to those observed in open surgery. The more severe the hip dysplasia, the worse the treatment outcome which also mirrors the results seen in open surgery.

FAI/labral tear
Grade C recommendation: one Level II, one Level III, four Level IV and two Level V studies
Opinion: in favor
The results in this section are similar to those seen in the adult literature. Philippon et al. (2008) caution surgeons to be conservative during osteoplasty of the femoral head and neck in patients with open physis. Ashberg et al. reported 157 patients with improved PROs prospectively with no difference between acute versus late treatment. Arthroscopy offers minimal morbidity and excellent to good outcomes, specifically return to sport in athletes.
Sequelae of DDH
Grade C recommendation: two Level IV and two Level V studies
Opinion: in favor
There is a high incidence of intra-articular pathology in patients presenting with symptoms secondary to DDH. Cartilage degeneration and labral tears are particularly common. The literature supports hip arthroscopy in the management of these abnormalities although caution should be exercised as the studies contain low number of patients and with paucity of long-term outcome data.

Septic arthritis
Grade C recommendation: four Level IV studies
Opinion: in favor
All four articles in this section outlined the benefit of hip arthroscopy in the pediatric patient with a septic hip.

Traumatic hip dislocation
Grade C recommendation: two Level IV and one Level V study
Opinion: in favor
The evidence supporting hip arthroscopy in the setting of a pediatric traumatic hip dislocation is limited. All articles in this section had successful outcomes for their patients after hip arthroscopy, noting that none were conducted in the acute phase (for those age under 20). We are in support of hip arthroscopy for posttraumatic hip dislocation in a delayed fashion.

Legg-Calve Perthes disease
Grade C recommendation: four Level IV and one Level V study
Opinion: in favor
All patients in the article by Roy (2005) had previous surgery whereas none had previous surgery in Freeman’s 2013 study. Both groups benefited from hip arthroscopy with minimal if any risks in the short term. Freeman et al. (2013) were clear to state that although hip arthroscopy does not alter the natural history of Perthes their patients had significant symptomatic improvements. This benefit was also apparent in the arthroscopic hydraulic mobilization study done by Majewski et al. [30]. Despite the positive results in Suzuki et al. [33] with 19 cases of hip arthroscopy in Perthes, follow-up was limited to 2 weeks.

Loose bodies
Grade C recommendation: three Level V studies
Opinion: in favor
All three articles in this section demonstrate excellent outcomes in patients who underwent arthroscopic removal of loose bodies of the hip.

Exostosis
Grade I recommendation: one Level V study
Opinion: insufficient
Ancillary imaging was paramount in the article by Bonomet et al. when assessing exostosis for hip arthroscopy.

Slipped capital femoral epiphysis
Grade I recommendation: one Level IV study
Opinion: insufficient
Leunig et al. promote the concept of hip osteoplasty in those with a mild SCFE at the time of pinning or as a staged procedure. Although outcomes were good for their patients, there is no long-term data to support SCFE as an indication for hip arthroscopy.

Extra-Articular pathology
Grade C recommendation: two Level V and two Level IV studies
Opinion: in Favor
Proximal hamstrings avulsion, external hip snapping syndrome and psoas impingement was treated successfully using arthroscopy. Ancillary imaging (MRI/MRA) was used in all cases. Caution was made for surgical experience in those approaching sciatic neurolysis in the proximal hamstrings avulsion.

Juvenile chronic arthritis
Grade I recommendation: one Level IV study
Opinion: insufficient
The authors in this study feel arthroscopy provided more information than the open procedure with respect to the acetabular cartilage, although assessment of the synovium was better in the open procedure.

CONCLUSION
Our results support our hypothesis. Despite the exponential increase in hip arthroscopy over the last decade, limited evidence exists in support of its use in the pediatric (≤18) population. Our findings support the need for further research in delineating the indications for its use, as clearly arthroscopy may be advantageous in many situations, particularly in light of the alternatives.

FUNDING
None.
CONFLICT OF INTEREST STATEMENT
None declared.

REFERENCES
1. DeAngelis NA, Busconi B, Research R. Hip arthroscopy in the pediatric population. Clin Orthop Relat Res 2003; 406: 60–3.
2. Byrd J. Hip arthroscopy: surgical indications. Arthroscopy 2006; 22: 1260–2.
3. Wright JG, Einhorn TA, Heckman JD. Grades of recommendation. J Bone Joint Surg Am 2005; 87:1909–10.
4. Xu H, Yang Y, Xu C et al. Effects of arthroscopic-assisted surgery on irreducible developmental dislocation of hip by mid-term follow-up: an observational study. Medicine 2016; 95: e4601.
5. Zhao L, Yan H, Yang C et al. Medium-term results following arthroscopic reduction in walking-age children with developmental hip dysplasia after failed closed reduction. J Orthop Surg Res 2017; 12: 135.
6. Öztürk H, Oztemür Z, Bulut O et al. Arthroscopic-assisted surgical treatment for developmental dislocation of the hip before the age of 18 months. Arch Orthop Trauma Surg 2013; 133: 1289–94.
7. Eberhardt O, Fernandez F, Wirth T. Arthroscopic reduction of the dislocated hip in infants. Arthroscopy 2012; 94: 842–7.
8. Kitano T, Imai Y, Morita M et al. New treatment method for developmental dysplasia of the hips after walking age: arthroscopic reduction with limboplasty based on the findings of preoperative imaging. J Orthop Sci 2010; 15: 443–51.
9. McCarthy JJ, MacEwen G. Hip arthroscopy for the treatment of children with hip dysplasia: a preliminary report. Orthopedics 2007; 30: 262–4.
10. Ashberg L, Walsh JP, Yuen LC et al. Outcomes of hip arthroscopy in adolescents: a comparison of acute versus chronic presentation. Two-year minimum follow-up. J Pediatr Orthop 2018; 38: e50–6.
11. Byrd JT, Jones KS, Gwathney F. Arthroscopic management of femoroacetabular impingement in adolescents. Arthroscopy 2016; 32: 1800–6.
12. Philippou MJ, Ejsnman L, Ellis HB et al. Outcomes 2 to 5 years following hip arthroscopy for femoroacetabular impingement in the patient aged 11 to 16 years. Arthroscopy 2012; 28: 1255–61.
13. Larson CM, Stone RM. The rarely encountered rim fracture that contributes to both femoroacetabular impingement and hip stability: a report of 2 cases of arthroscopic partial excision and internal fixation. Arthroscopy 2011; 27: 1018–22.
14. Sekiya JK, Martin RL, Lesniak BP. Arthroscopic repair of delaminated acetabular articular cartilage in femoroacetabular impingement. Orthopedics 2009; 32: 692.
15. Philippou MJ, Yen YM, Briggs KK et al. Early outcomes after hip arthroscopy for femoroacetabular impingement in the athletic adolescent patient: a preliminary report. J Pediatr Orthop 2008; 28: 705–10.
16. McCarthy J, Barsoum W, Puri L et al. The role of hip arthroscopy in the elite athlete. Clin Orthop Relat Res 2003; 406: 71–4.
17. Ikeda T, Awaya G, Suzuki S et al. Torn acetabular labrum in young patients. Arthroscopic diagnosis and management. J Bone Joint Surg Br 1988; 70: 13–6.
18. Larson CM, Kelly BT, Stone R. Making a case for anterior inferior iliac spine/subspin hip impingement: three representative case reports and proposed concept. Arthroscopy 2011; 27: 1732–7.
19. Klein SE, Morgan P, Schoenecker PL et al. Arthroscopic treatment of labral tears after a previous Pemberton osteotomy. J Pediatr Orthop 2010; 30: 549–53.
20. Fuji M, Nakashima Y, Jingushi S et al. Intraarticular findings in symptomatic developmental dysplasia of the hip. J Pediatr Orthop 2009; 29: 9–13.
21. Ilizaliturri VM Jr, Chaidez PA, Valero FS et al. Hip arthroscopy after previous acetabular osteotomy for developmental dysplasia of the hip. Arthroscopy 2005; 21: 176–81.
22. Sanpera I, Raluy-Collado D, Sanpera-Iglesias J. Arthroscopy for hip septic arthritis in children. Orthop Traumatol Surg Res 2016; 102: 87–9.
23. Nusem I, Jabur MK, Playford E. Arthroscopic treatment of septic arthritis of the hip. Arthroscopy 2006; 22: 902.e1–3.
24. Chung WK, Slater GL, Bates E. Treatment of septic arthritis of the hip by arthroscopic lavage. J Pediatr Orthop 1993; 13: 444–6.
25. Blitzer C. Arthroscopic management of septic arthritis of the hip. Arthroscopy 1993; 9: 414–6.
26. Morris AC, Yu JC, Gilbert SR. Arthroscopic treatment of traumatic hip dislocations in children and adolescents: a Preliminary Study. J Pediatr Orthop 2017; 37: 435–9.
27. Philippou MJ, Kuppersmith DA, Wolff AB et al. Arthroscopic findings following traumatic hip dislocation in 14 professional athletes. Arthroscopy 2009; 25: 169–74.
28. Kashiwagi N, Suzuki S, Seto Y. Arthroscopic treatment for traumatic hip dislocation with avulsion fracture of the ligamentum teres. Arthroscopy 2001; 17: 67–9.
29. Freeman CR, Jones K, Byrd J. Hip arthroscopy for Legg-Calve-Perthes disease: minimum 2-year follow-up. Arthroscopy 2013; 29: 666–74.
30. Majewski M, Hasler CC, Kohler G. Arthroscopic mobilization of the hip joint in children with aseptic necrosis of the femur head. J Pediatr Orthop B 2010; 19: 135–9.
31. Roy D. Arthroscopic findings of the hip in new onset hip pain in adolescents with previous Legg-Calve-Perthes disease. J Pediatr Orthop B 2005; 14: 151–5.
32. Kuklo TR, Mackenzie WG, Keeler K. Hip arthroscopy in Legg-Calve-Perthes disease. Arthroscopy 1999; 15: 88–92.
33. Suzuki S, Kasahara Y, Seto Y et al. Arthroscopy in 19 children with Perthes’ disease: pathologic changes of the synovium and the joint surface. Acta Orthop Scand 1994; 65: 581–4.
34. Nepple JJ, Schoenecker PL, Clohisy JC. Treatment of posttraumatic labral interposition with surgical hip dislocation and labral repair. Iowa Orthop J 2011; 31: 187–92.
35. Kusma M, Jung J, Dienst M et al. Arthroscopic treatment of an avulsion fracture of the ligamentum teres of the hip in an 18-year-old horse rider. Arthroscopy 2004; 20: 64–6.
36. Byrd JW. Hip arthroscopy for posttraumatic loose fragments in the young active adult: three case reports. Clin J Sport Med 1996; 6: 129–33; discussion 33–4.
37. Bonnomet F, Clavert P, Abidine FZ et al. Hip arthroscopy in hereditary multiple exostoses: a new perspective of treatment. Arthroscopy 2001; 17: E40.
38. Leunig M, Horowitz K, Manner H et al. In situ pinning with arthroscopic osteoplasty for mild SCFE: a preliminary technical report. *Clin Orthop Relat Res* 2010; 468: 3160–7.

39. Lindner D, Trenga AP, Stake CE et al. Endoscopic repair of a chronic incomplete proximal hamstring avulsion in a cheerleader. *Clin J Sport Med* 2014; 24: 83–6.

40. Zini R, Munegato D, De Benedetto M et al. Endoscopic iliotibial band release in snapping hip. *Hip Int* 2013; 23: 225–32.

41. Kunac N, Trsek D, Medancic N et al. Endoscopic treatment of the external snapping hip syndrome: surgical technique and report of two cases. *Acta Clin Croat* 2012; 51: 661–6.

42. Anderson SA, Keene JS. Results of arthroscopic iliopsoas tendon release in competitive and recreational athletes. *Am J Sports Med* 2008; 36: 2363–71.

43. Holgersson S, Brattstrom H, Mogensen B et al. Arthroscopy of the hip in juvenile chronic arthritis. *J Pediatr Orthop* 1981; 1: 273–8.