Arthroscopy of the hip for paediatric and adolescent disorders

CURRENT CONCEPTS

Hip arthroscopy is particularly attractive in children as it confers advantages over arthrotomy or open surgery, such as shorter recovery time and earlier return to activity. Developments in surgical technique and arthroscopic instrumentation have enabled extension of arthroscopy of the hip to this age group. Potential challenges in paediatric and adolescent hip arthroscopy include variability in size, normal developmental change from childhood to adolescence, and conditions specific to children and adolescents and their various consequences. Treatable disorders include the sequelae of traumatic and sports-related hip joint injuries, Legg–Calve–Perthes’ disease and slipped capital femoral epiphysis, and the arthritic and septic hip. Intra-articular abnormalities are rarely isolated and are often associated with underlying morphological changes.

This review presents the current concepts of hip arthroscopy in the paediatric and adolescent population, covering clinical assessment and investigation, indications and results of the experience to date, as well as technical challenges and future directions.

Indications for hip arthroscopy
The indications for hip arthroscopy in children and adolescents are less well defined than in adults.2–8 Intra-articular abnormalities are rarely isolated and are often associated with underlying morphological changes.9–11,13,15 Contraindications include moderate to severe limitation of movement, the presence of heterotopic bone and severe osteoarthritis with joint space narrowing > 50%.11 The presence of obesity that accompanies some cases of post-SCFE deformity is only a relative contraindication, the technical difficulties and risks being outweighed by the benefits derived from hip arthroscopy.11,12,16,17

Clinical assessment
Hippain may be experienced in the groin or laterally, around or proximal to the greater trochanter. It may also be referred to the thigh or knee. Snapping may represent intra-articular pathology such as a labral or ligamentum teres tear, or impingement of the iliobibial band or iliopsoas tendon against a bony prominence.18 The patient may demonstrate Byrd’s ‘C-sign’,13 in which they hold their thumb and index finger in the shape of a ‘C’ centred on and spanning a region over the greater
trochanter. On examination pain may be elicited during a log-roll manoeuvre with pressure on the affected side, suggesting intra-articular pathology. Limitation of internal rotation is associated with cam-type femoroacetabular impingement (FAI), femoral retroversion or progressive cartilage degeneration. A full assessment of gait and neurovascular status should also be performed. Special tests include the impingement sign, McCarthy’s sign, FABER test (Flexion-Abduction-External rotation) and the ‘figure of four’ position test. The impingement sign is positive when pain is experienced with flexion, adduction and internal rotation of the hip, and is indicative of intra-articular pathology, such as labral tear or FAI. McCarthy’s sign is positive when there is pain during extension, with both hips initially fully flexed, and the tested hip extended first in internal then external rotation. The FABER test involves flexion, abduction and external rotation, and the ‘figure of four’ position tests for problems related to the sacroiliac joint, FAI or psoas muscle pathology.

Investigations
Imaging techniques that should be considered prior to arthroscopy include conventional radiography, CT, MRI and MR arthrography (MRA). Standard radiographs comprise supine anteroposterior (AP) pelvis and frog-leg lateral views to assess for dysplasia, malalignment and FAI. Special views include cross-table lateral, false profile, abduction/adduction and Dunn lateral views to enable assessment of the femoral head–neck junction and cam lesions. Ace-tabular version is assessed by comparing the positions of the anterior and posterior acetabular walls. Retroversion is indicated by the cross-over and posterior wall signs on radiographs with the pelvis in neutral rotation and normal inclination.

CT and reconstruction images may allow clearer visualisation of the joint, skeletal anatomy and bony impingement. However, the benefits must be weighed against the risks of radiation exposure, especially in young females.

MRI and MRA allow greater definition of intra-articular pathology, including labral and chondral abnormalities, as well as evaluating the contour of the femoral head–neck junction in FAI (Fig. 3). High-resolution surface coils in sagittal, coronal and axial planes are essential. MRI without contrast has been reported to be successful in identifying labral and chondral abnormalities in patients...
prior to arthroscopy. However, several studies report a high false negative rate with MRI without intra-articular contrast. Other studies have demonstrated the improved diagnostic advantages of MRA and report increased levels of sensitivity, specificity and accuracy. Both CT and MRI have been used to calculate the α angle and predict the risk of anterior impingement. Delayed gadolinium-enhanced MRI of cartilage (dGEMRIC) is designed to demonstrate the biochemical integrity of articular cartilage as reflected by features such as the glycosaminoglycan content. It provides a quantitative assessment of the development of osteoarthritis, especially at early, pre-radiological stages. The dGEMRIC index has been correlated with pain and severity of hip dysplasia, early osteoarthritis in FAI, and follow-up of patients with SCFE and Perthes’ disease.

Surgical technique and challenges
The technique of hip arthroscopy is similar to that used in adults and is well described elsewhere. Careful positioning of the patient is essential. The proximal femoral anatomy dictates the degree of abduction required. There are no data in the literature regarding the appropriate traction force or fluid pressure required to create adequate joint distension in children.

Various anatomical and pathoanatomical features make arthroscopy of the hip in the children and adolescents technically challenging. Hip joint anatomy in this group is more variable than in adults, and the size of the joint clearly varies with age. There is a significant decrease in the neck-shaft angle (approximately 155° to 130°) and degree of anteversion (approximately 40° to 10°) from neonate to adult. The physis must also be respected in the skeletally immature patient. Advances in instrumentation, such as smaller arthroscopes and instruments, can overcome the limitations posed by a smaller hip joint, but the surgeon must still appreciate the variability of joint morphology in children.

Any technical challenges encountered will depend on the underlying pathology. For example, in Perthes’ disease, deformities of the proximal femur, such as coxa magna or coxa breva, may make arthroscopic assessment of the peripheral compartment of the hip more difficult. The position and shape of the femoral head in DDH and SCFE may also limit access to both central and peripheral compartments.

Complications
Complications associated with hip arthroscopy are well described and can be classified as traction related or direct injury. However, there are no studies that specifically investigate complications in the young patient. Complications of hip arthroscopy in general include neurapraxia, iatrogenic chondral damage, broken guide wires, damage to the lateral femoral cutaneous nerve, femoral neck fracture, vascular insult to the femoral head, fluid extravasation, myositis ossificans and heterotopic ossification.

Results
In a retrospective study of a mixed adolescent and adult population, hip arthroscopy was found to give good results in patients with labral tears, loose bodies, focal chondral lesions and the late sequelae of Perthes’ disease, but poorer outcomes in patients with osteonecrosis or degenerative joint disease. Kocher and Lee reported the early results of 54 hip arthroscopies in 42 children and adolescents up to 18 years of age over a three-year period with a minimum follow-up of one year. A significant overall improvement in the modified Harris hip score (HHS) was observed in patients with isolated labral tears undergoing labral debridement, post-Perthes’ disease hips undergoing chondroplasty and loose body excision, and labral debridement in hip dysplasia after prior peri-acetabular osteotomy.

Hip dysplasia. Favourable results have been reported in the arthroscopic management of intra-articular pathology in dysplastic hips; however, definitive treatment of the underlying dysplasia by peri-acetabular osteotomy with or without proximal femoral osteotomy is still of paramount importance. Fujii et al reported a high incidence of acetabular cartilage degeneration and anterosuperior labral tears in 22 adolescent patients with symptomatic sequelae of DDH who underwent arthroscopy prior to corrective osteotomy.

Untreated intra-articular pathology may adversely affect the outcome of reconstructive procedures for the correction of deformity, such as acetabular realignment or augmentation. This has led to recommendations for staged treatment in such cases, with arthroscopic evaluation prior to reconstruction. This enables the labrum to be assessed and repaired if possible, as well as allowing good visualisation of the articular surfaces, the quality of which may influence the choice of reconstructive procedure. McCarthy and MacEwen reported the use of hip arthroscopy in the management of failed closed reduction in children with DDH under two years of age. Bulut et al reported the arthroscopically assisted treatment of failed closed reduction in four children with DDH ranging from 11 to 14 months. Both investigators reported good visualisation of the pathoanatomy and successful debridement of the hypertrophic ligamentum teres, transverse acetabular ligament and pulvinar tissue. Arthroscopic debridement has also been shown to improve mechanical symptoms and pain in patients with DDH who have previously undergone peri-acetabular osteotomy and reconstructive procedures, provided they do not have advanced degenerative joint disease.

Perthes’ disease and avascular necrosis. Arthroscopic findings of the hip in early Perthes’ disease include dilatation of the peri-chondral vascular ring, flattening of the femoral head, fibrillation of cartilage, and labral hypertrophy and synovial proliferation in the acetabular fossa and inner capsule. Arthroscopy has also been used to stage and classify avascular necrosis of the femoral head prior to revascularisation and arthroscopic core decompression and drilling.
There are no clear indications for arthroscopic intervention at an early stage in children with active Perthes’ disease. Arthroscopic hydraulic hip distension under epidural anaesthesia with post-operative physiotherapy in a brace, in order to increase the range of movement of the hip, has been successfully used in young patients with Perthes’ disease following failed conservative treatment with a minimum follow-up of one year.

The adolescent or young adult may present with various intra-articular sequelae of earlier Perthes’ disease and the abnormal mechanics resulting from the residual deformity. The diagnostic value of arthroscopy in assessing patterns of abnormality and degeneration prior to reconstructive procedures in Perthes’ disease have been clearly described. In adolescent patients intra-articular abnormalities, including tears of the ligamentum teres, osteochondritis dissecans of the femoral head, labral tears and severe synovitis, have been successfully treated. Removal of loose bodies and debridement of cartilaginous flaps were the most successful procedures. Arthroscopic chondroplasty of unstable osteochondral lesions of the femoral head has also been shown to provide significant symptomatic and functional improvement in children with the sequelae of Perthes’ disease. Anterosuperior flattening of the femoral head and cam impingement secondary to reduced femoral head–neck ratio in conjunction with consistent patterns of labral and acetabular chondral damage have been reported. However, following arthroscopic intervention the long-term prognosis of patients with substantial femoral head deformity and asphericity is unclear.

**Slipped capital femoral epiphysis (SCFE).** There is increasing evidence that SCFE, including mild slips, can lead to early-onset osteoarthritis mediated via mechanical damage from FAI. Anterior labral tears may occur as a result of anterior impingement in patients with pistol-grip deformity. Articular cartilage damage, full-thickness loss and delamination have been observed at the time of surgery, particularly in stable slips. Studies of children with SCFE who have been treated by surgical dislocation or arthroscopy have highlighted consistent patterns of mechanical damage, including labral damage and partial- or full-thickness loss of adjacent acetabular cartilage.

Futami et al arthroscoped five patients with acute or chronic SCFE prior to in situ fixation. They reported synovitis, intra-articular haematoma, erosion of the acetabular cartilage in the anterosuperior region, transverse clefts and cartilaginous erosions on the anterior surface of the femoral head, and damage to the posterosuperior aspect of the labrum. They recommended that arthroscopy should be followed immediately by in situ fixation. The preceding arthroscopic surgery appeared to reduce hip pain and allow earlier movement of the hip. Leunig et al recently reported the treatment of three patients with mild slips and signs of impingement with in situ stabilisation followed by immediate arthroscopic femoral neck osteoplasty. They observed labral fraying, acetabular chondromalacia, and a prominent metaphyseal ridge arthroscopically, and demonstrated subsequent resolution of impingement and restoration of movement.

There are, however, no studies defining the indications, patterns of injury and outcomes of arthroscopic surgery in patients with pathology following treated SCFE.

**Femoroacetabular impingement (FAI).** FAI can be classified into cam, pincer and mixed types. It may cause pain, limitation of movement and further soft-tissue injury, including damage to the labrum, synovium and cartilage. Cam-type FAI is caused by a reduced femoral head–neck offset and involves a morphological abnormality in the shape and contour of the femoral head–neck junction, specifically an abnormal extension of the capital femoral epiphysis. Cam lesions cause impingement and shear against the acetabular rim when the hip is flexed and internally rotated, leading to damage of the chondrolabral complex.

Pincer-type FAI is due to an abnormality of acetabular morphology causing over-coverage of the femoral head leading to impaction against the femoral head and labral tears. Abnormal acetabular morphology may be due to generalised protrusion or acetabular retroversion, which may be primary, or secondary to previous corrective procedures such as triple or peri-acetabular osteotomies. Cam-type impingement tends to cause transition zone cartilage damage in the weight-bearing anterosuperior zone, whereas pincer-type impingement primarily causes crush damage to the labrum.

Traditional treatment of FAI by open surgical dislocation, labral repair or re-fixation and femoral head–neck osteoplasty, is being replaced by arthroscopy in the adult. Arthroscopy has also been used in adults to treat FAI secondary to paediatric hip disorders, with good anatomical and functional outcomes. A systematic review by Bedi et al reported that as good results may be obtained following arthroscopy in the treatment of labral tears and FAI in young patients as following the variety of open procedures reported in the literature.

Philippon et al reported excellent early outcomes, significant improvements in function and high patient satisfaction in 16 adolescent athletes undergoing hip arthroscopy for cam, pincer and mixed-type FAI. All had labral pathology and were treated with labral suture-anchoring repair or partial debridement.

**Septic arthritis.** The principles of treatment of septic arthritis involve decompressing the hip, reducing the bacterial load, debriding loculations and eliminating collections. Arthroscopy can be used to obtain tissue and fluid samples, debride the joint and damaged tissue, remove debris, lavage the joint and establish drainage in a minimally invasive manner. Several studies have shown successful outcomes in both adults and children following arthroscopy combined with antibiotic treatment, although some authors have advocated open arthrotomy via a limited anterior approach to facilitate capsulotomy, drain placement, and...
drilling of the femoral neck to rule out associated osteomyelitis.\textsuperscript{14} Chung, Slater and Bates\textsuperscript{63} reported nine cases of septic arthritis of the hip in children aged two to seven years that were successfully treated by arthroscopic lavage using large-bore high-volume lavage until clear fluid output was observed, with direct suction to remove debris, post-operative suction drainage and three to six weeks of antibiotic treatment. Kim et al\textsuperscript{64} also reported excellent results in eight patients ranging from two to 14 years of age treated by arthroscopic drainage and debridement. El-Sayed,\textsuperscript{65} in a prospective controlled study randomised for arthroscopy \textit{versus} arthrotomy, compared open arthrotomy with arthroscopic drainage in 20 children with acute septic arthritis. They concluded that there was no significant difference in outcome between these forms of treatment, and recommended arthroscopic lavage in the hands of a skilled arthroscopic surgeon as a suitable alternative to arthrotomy early on in uncomplicated cases of septic arthritis. Rutz and Brunner\textsuperscript{66} also recommended the use of repeated arthroscopic irrigation in young patients with a short history and without radiological signs of complications, and arthrotomy in those with a longer history or with radiological evidence of local defects or dislocation.

**Trauma and sports injuries.** Following traumatic hip dislocation or fracture-dislocation, children with residual joint problems have in the past been treated by arthrotomy to deal with osteochondral fragments, torn ligamentum teres or a torn acetabular labrum and capsule.\textsuperscript{68,69} Kashiwagi, Suzuki and Seto\textsuperscript{70} reported the successful arthroscopic excision of an avulsed ligamentum teres that was interposed in the hip joint causing incongruous closed reduction in a ten-year-old with traumatic dislocation of the hip. Roy\textsuperscript{11} removed a torn detached posterior labrum in one child, and performed microfracture of a large impaction lesion of the anterior femoral head with debridement of tears of the posterior labrum and ligamentum teres in another.

Less severe intra-articular injuries include labral tears, ligamentum teres tears, chondral or osteochondral lesions and loose bodies with or without synovitis.\textsuperscript{71,72} The typical presentation is of a young athlete such as a gymnast, skater or dancer reporting a traumatic event during activity involving hip flexion, abduction and knee extension, leading to groin pain and a reproducible painful click in the inguinal region due to a labral tear.\textsuperscript{5,11,14} Isolated labral tears in the absence of an anatomical deformity or underlying primary condition are well described.\textsuperscript{12,69,73,74} Repetitive activity involving flexion, flexion–abduction or extension–external rotation are linked to an increased risk of anterior labral tears.\textsuperscript{14}

Satisfactory and reproducible results using hip arthroscopy in the young athlete have been reported.\textsuperscript{75} Reproducible mechanical symptoms, such as snapping, clicking and locking, warrant arthroscopic intervention, especially if conservative measures have failed.\textsuperscript{75} Studies on arthroscopic debridement and repair of labral tears in children and adolescents, and cohorts including adolescent patients, have demonstrated improvement in symptoms, function and modified Harris hip score.\textsuperscript{12,26,76} The current trend is to preserve and repair the labrum if possible.\textsuperscript{5,55,72} The vascularity of the labrum in the child is superior to that in the adult, and a better understanding of the zonal vascular supply of the labrum may lead to improved outcomes after labral repair in this age group.\textsuperscript{19,20}

**Miscellaneous.** Other applications include excision of hereditary multiple exostoses within the acetabular fossa\textsuperscript{77} and the treatment of synovial chondromatosis.\textsuperscript{78} Holgersson et al\textsuperscript{79} reported the use of hip arthroscopy in 13 patients with juvenile chronic arthritis and observed improved visualisation of the cartilage and improved pain relief and function with arthroscopic synovectomy in cases where medical therapy failed to control symptoms. Hip arthroscopy has been used successfully to biopsy and excise intra-articular osteoid osteomas.\textsuperscript{80}

Hip arthroscopy can be used to identify intra-articular pathology and treat problems amenable to debridement or repair. In children and adolescents, challenges include variability in the size of the patient, the presence of underlying morphological variations and the effect of pre-existing disorders such as DDH, Perthes’ disease, SCFE and FAL.\textsuperscript{81} Arthroscopy may also be an important initial step prior to open reconstructive procedures.

It should be noted that current studies often lack statistical power and control groups. Moreover, tools used for the assessment of outcome, such as the modified Harris hip score, have not been validated for use in children and adolescents.\textsuperscript{39} Health-related quality of life questionnaires exist for the population, but these do not relate specifically to the young person’s hip.\textsuperscript{82} Outcome measures specific to hip arthroscopy are now being developed.\textsuperscript{34} Long-term and epidemiological studies will help to determine the potential and importance of arthroscopic intervention as a diagnostic and therapeutic procedure.

In conclusion, hip arthroscopy offers an attractive alternative to open surgery. Ongoing work will more clearly define the indications and present the results of this procedure for specific paediatric and adolescent hip disorders.

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**References**


