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Hip Arthroscopy as Part of a Salvage Procedure for Avascular Necrosis (AVN) in a 7-Year-Old Child

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

ABCDEF Ioannis Delniotis
ACDEFG Benedikt Leidinger

Department of Pediatric- and Neuro-Orthopedics, Foot and Ankle Surgery, Orthopedic Clinic Volmarstein, Wetter (Ruhr), Germany

Corresponding Author: Ioannis Delniotis, e-mail: ioannis.delniotis@gmail.com
Conflict of interest: None declared

Patient: Female, 7
Final Diagnosis: Femoroacetabular (CAM) impingement
Symptoms: Hip pain • limitation of movement of the hip
Medication: —
Clinical Procedure: Femoral osteotomy and acetabuloplasty – hip arthroscopy
Specialty: Orthopedics and Traumatology

Objective: Unusual setting of medical care

Background: Avascular necrosis of the femoral head (AVN) is one of the most serious complications following developmental dysplasia of the hip (DDH). Treatment options focus mainly on improving the biomechanics and kinematics of the affected hip joint. In the past, femoral and pelvic osteotomies were the mainstay of treatment. Over the last years, the use of hip arthroscopy has also grown and allows reconstructive treatments in pediatric hip disorders.

Case Report: We present a 7-year old patient with AVN of the proximal femoral head after open reduction of her dislocated hip (DDH). The patient presented to our department with limb length discrepancy, limited internal rotation of the right hip and groin pain. We performed a two-stage procedure including a) valgus proximal femur osteotomy combined with Dega acetabuloplasty and b) hip arthroscopy to address the formation of CAM impingement that was the result of excessive femoral head necrosis and our re-orientation procedure.

Conclusions: AVN following closed or open reduction for DDH is a potentially devastating complication. Hip arthroscopy can be an extremely useful tool that can be used in addition to the well-known osteotomy procedures to improve joint congruency. Hip arthroscopy in the pediatric population is a new growing field that can be used in managing disorders of the pediatric hip, as the indications will continue to evolve.

MeSH Keywords: Arthroscopy • Femur Head Necrosis • Hip Dislocation, Congenital • Osteotomy

Full-text PDF: https://www.amjcaserep.com/abstract/index/idArt/916804

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Background

Developmental dysplasia of the hip (DDH) is a term used to describe a wide spectrum of abnormalities between the femoral head and the acetabulum [1–3]. This spectrum of diseases can range from acetabular dysplasia without displacement to subluxation of the femoral head or dislocation of it [1,2]. In fact, any abnormality in the size, shape, and orientation in the pediatric hip joint can be included in this spectrum of diseases under the term DDH [3]. Early diagnosis and treatment are critical to prevent secondary osteoarthritis of the hip [4].

One of the most serious and devastating complications after treatment of DDH is avascular necrosis of the femoral head (AVN) [5]. The reported incidence of the AVN in the literature ranges from 0% to 60% [6,7]. This wide variation is due to the variable severity of DDH, diverse types of treatment and immobilization, and differences in patient age, follow-up, and classification of AVN [7]. Severe AVN causes serious hip dysfunction with ROM (range of motion) restriction, early osteoarthritis, and limb-length discrepancy, with the need of further surgical interventions [8].

We present the case of a 6-year-old girl with AVN of the femoral head following open reduction of hip dislocation. The patient presented with severe limited internal rotation of the right hip joint and groin pain. We performed a two-stage strategy method with a) valgus osteotomy of the proximal femur combined with acetabuloplasty and b) metal removal and hip arthroscopy to reshape the congruency of the proximal femur and improve her motion.

Case Report

A 6-year-old girl presented to our department with symptoms of severe limping, limited internal rotation of the right hip joint, and pain in the right hip joint. The patient's history included a premature birth at 30 weeks and a right hip dislocation detected for the first time at the age of 6 months (in February 2011) (Figure 1A, 1B). The initial treatment took place in another country and included attempts at closed reduction, which were unsuccessful. The decision to perform open reduction was postponed due to a severe bacterial infection and took place 8 months later (November 2011). A hip-spica and a K-wire were used for stabilization of the relocated right hip (Figure 1C). Unfortunately, no more details regarding the open reduction (medial or anterolateral approach) could be obtained from the family. The post-operative MRI a few weeks later (December 2011) revealed an AVN of the femoral head (Figure 1D). The following treatment after the hip-spica included an abduction orthosis for another 6 months (Figure 1E). The final result at the age of 2 years was a severe incongruency of the right hip joint and coxa vara (Figure 1F). No further intervention was performed, and physiotherapy was proposed at this time.

Four years later, at the time of first presentation in our department, the clinical examination revealed a limb-length discrepancy of 2 cm (right leg shorter) and a limited internal rotation, with only 10° of the right hip. X-ray images of both hips revealed a significant reduced centrum-collum-diaphyseal (CCD) angle of 90°, shortening of the femoral neck, a significant prominent major trochanter, and a pathologic acetabular index angle of 25° of the right hip joint (Figure 2A). An MRI was also performed, indicating necrosis of the femoral head and the joint incongruency (Figure 2B). Our aim was to address the acetabular dysplasia, the significant coxa vara, and the internal rotation deficit of the hip. Therefore, we performed a valgus derotation osteotomy of the proximal femur (30° valgus, 25° rotation) combined with an 18-mm shortening osteotomy of the proximal femur and a Dega acetabuloplasty in order to correct the CCD angle and the internal rotation of the hip (Figure 2C). Adapted femoral shortening of 18 mm was necessary to prevent increased joint pressure related to the possible effects of femoral lengthening by 30^0 valgus osteotomy and the improved lateral coverage by the pelvic osteotomy. The acetabular index angle was 25° before surgery and 15° after surgery. The internal rotation of the hip joint was 25° at this time.

One year after this surgical intervention at the age of 7 years, the patient presented again with limited internal rotation and pain with flexion, adduction, and internal rotation of the right hip. The clinical examination revealed an 80° external rotation with 5° of internal rotation of the right hip. The X-ray examination of the right hip revealed a secondary CAM formation at the anterior femoral neck (Figure 2D, 2E). An arthroscopic resection of the CAM was performed. Intra-operatively, it was clear that excessive bone was formed in the ventral region of the femoral neck, and this was excised (Figure 3A–3C) arthroscopically with a burr. After resection of the bump, the underlying growth plate became visible and could be easily respected without any damage. Metal-plate removal was also performed. Figure 4 shows the final result after resection of the bump.

Follow-up

In the final follow-up, 1 year later (2019), our patient has no more limping, the external rotation of the hip is 80°, and the internal rotation is 15°. The X-ray imaging shows that CAM formation at the anterior femoral neck starts to show up again (Figure 5). Flexion, extension, abduction, and adduction of the affected hip joint are unrestricted. The patient reports that the episodes of pain are significantly reduced, although not eliminated. The patient's satisfaction was assessed by using

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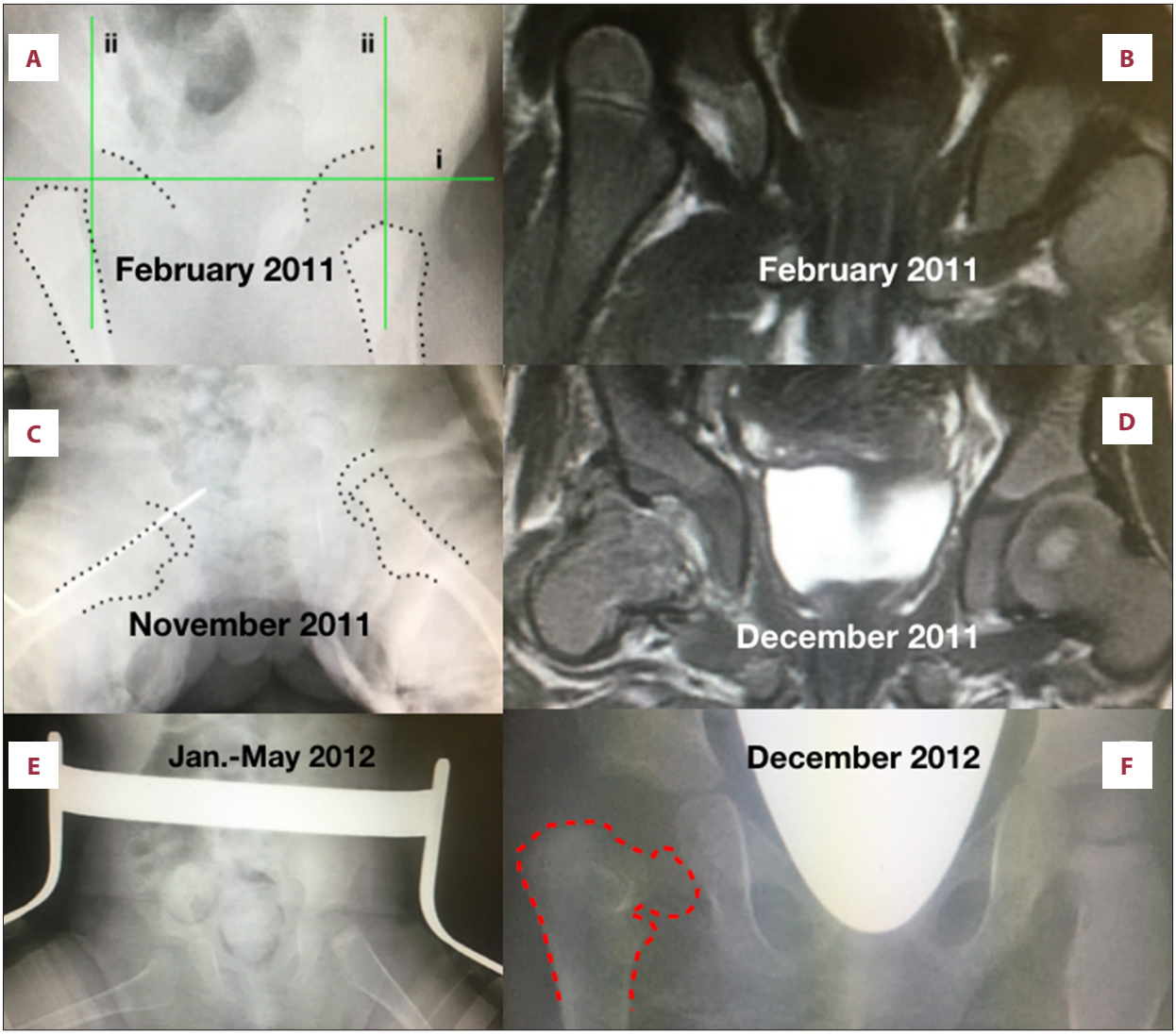

Figure 1. (**A**) The first X-ray of our patinet, showing right hip dislocation. i=indicating Hilgenreiner line, ii=indicating Perkins line. (**B**) MRI showing the right hip dislocation. (**C**) X-ray of our patient after open reduction and use of hip-spica and K-wire for stabilization. (**D**) MRI of our patient showing collapse and fragmentation of the femoral head (AVN). (**E**) Abduction orthosis used 6 months after open reduction. (**F**) X-ray of our patient at 2 years of age. Femoral head necrosis is obvious.

the Visual Analogue Scale (score of 0=no pain and score of 100=worst pain imaginable). Before valgus osteotomy and Dega pelvic osteotomy, the patient indicated a score of 80 (severe pain). After this operation and before hip arthroscopy, the patient indicated a score of 60 (moderate pain), and at the final follow-up at 1 year, she gave a score of 35 (mild pain). Regarding the "new" CAM formation, we decided not to proceed with a second hip arthroscopy at this time, but rather to evaluate the progress and the clinical status of the patient every 6 months. Regarding the limb-length discrepancy, close follow-up will be performed every 6 months, with a proposal of contralateral epiphysiodesis at an appropriate time.

Discussion

Avascular necrosis of the femoral head remains still one of the most serious and poorly understood complications of the treatment of DDH [9]. The most commonly proposed mechanism of ischemia in patients treated with closed reduction for DDH is an interruption of the blood flow due to reduction manipulation or/and excessive pressure of the femoral head in the spica-cast [7,10]. On the other hand, open reduction is also associated with AVN of the femoral head. Wang et al. concluded in their study that open reduction is a more serious risk factor for AVN compared with closed reduction [11]. They state that during open reduction, the medial femoral circumflex artery (which is the main blood supply of the femoral head) can be

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Figure 2. (**A**) X-ray of our patient at time of presentation. Reduced CCD angle, shortening of the femoral neck, and prominent major trochantor are obvious. (**B**) MRI showing AVN of the femoral head at age 6 years. (**C**) Valgus derotation osteotomy of the proximal femur combined with Dega acetabuloplasty (with use of bone graft). (**D, E**) Anteroposterior and profile view 1 year after revealing CAM formation at the anterior femoral neck.

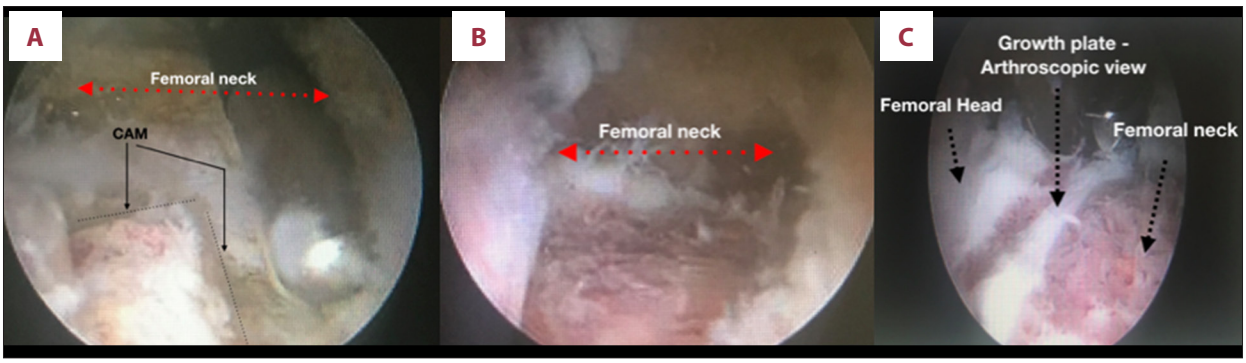

Figure 3. Hip arthroscopy in a 7-year-old child: (**A**) Arthroscopic view of CAM an anterior femoral neck. (**B**) Arthoscopic view after resection of CAM. (**C**) Arthoscopic view of growth plate. It is imperative to recognize the growth plate in order not to damage it.

easily injured or needs to be ligated [11]. Extrinsic compression of blood vessels combined with excessive pressure of the femoral head is the second most common mechanism of ischemia, which can be encountered when there are repeated attempts at reduction [12].

Diagnosis of AVN

The diagnosis of AVN can be very challenging as there is usually a delay between the time of the initial ischemia and the time that radiological changes present, which in some cases may

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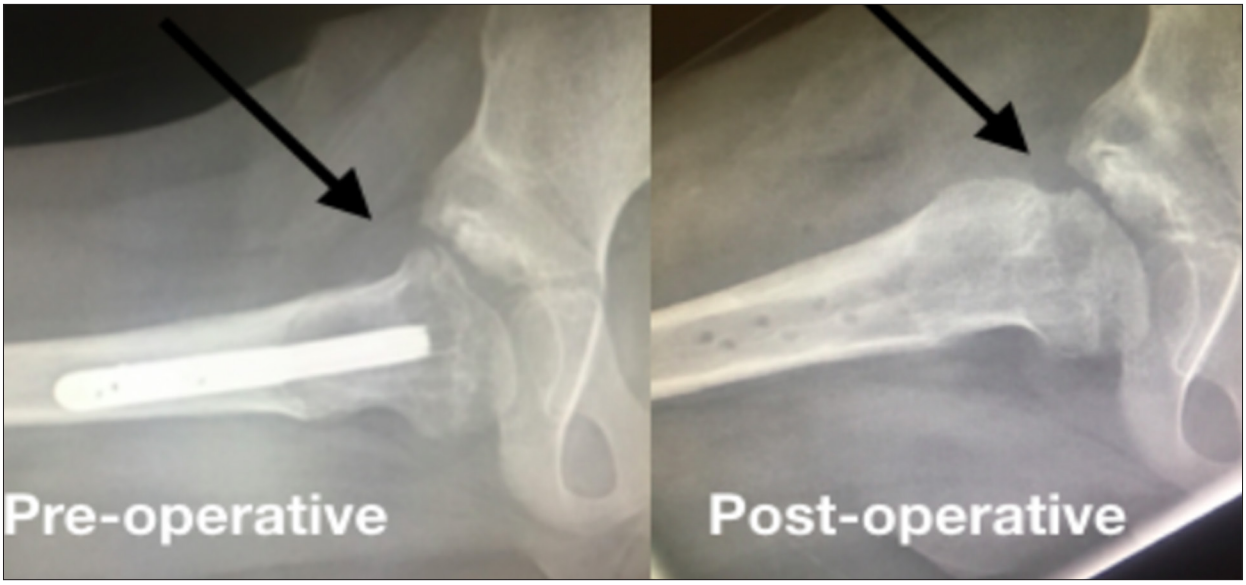

Figure 4. Pre-operative and post-operative X-ray (Lauenstein view) after plate removal, hip arthroscopy, and resection of CAM in our 7-year-old patient. The arrow shows the location of the CAM that no longer exists after hip arthroscopy.

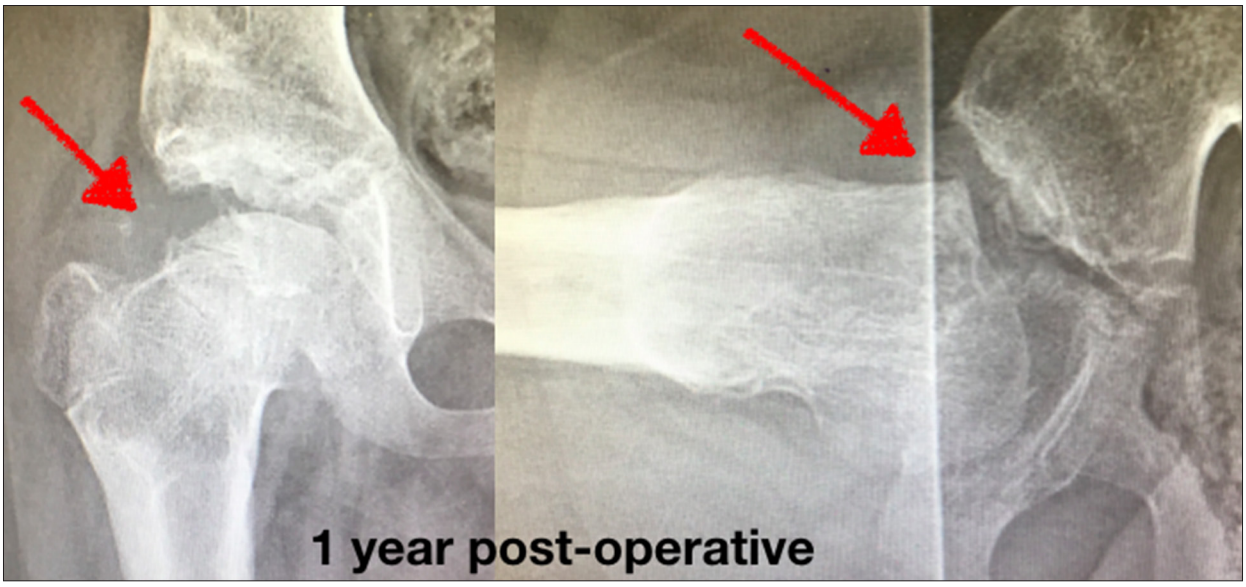

Figure 5. X-ray (f + Lauenstein view) at 1-year follow-up, after hip arthroscopy. A "new" CAM formation starts to appear at the femoral head-neck junction (red arrow). In comparison with the X-rays before hip arthroscopy (Figure 4), there is less new bone formation.

be evident even 12 years after treatment [13]. In our patient, we strongly suspected that AVN of the femoral had already occurred before the open reduction (November 2011) when closed reduction was attempted (February 2011). We came to this conclusion taking into account the significant fragmentation and the collapse of the femoral head in the MRI performed a few weeks after the open reduction. Early diagnosis is very important as early intervention can (partially) reverse the necrosis or at least can prevent a join incongruity and early osteoarthritis [5,14]. Gornitzky et al. reported that gadolinium-enhanced perfusion MRI is an extremely useful tool for early diagnosis because it can help evaluate the femoral head vascularity [14].

Prevention of AVN

Regarding the prevention of AVN after treatment of DDH, many factors have been studied. Wang et al. found that open reduction and patients aged >18 months at the time of reduction are risk factors that increase the risk of developing AVN [11].

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The age of the patient seems to play a significant role, proven by various studies, as the younger patients tend to have better over-all functional and radiological results [13,15]. Increased rates of AVN are also observed in patients treated with wide abduction and internal rotation [16]. Although there is no exact limit beyond which AVN will definitely appear, Smith et al. found no AVN if the abduction was under 55° [16]. More questionable is the pre-reduction traction. Some studies found no significant reduction in rates of AVN in children younger than 1 year old, and discussed the heterogeneity between studies (at home or in-patient traction, weight and time of traction, taking into account other factors such as age, closed or open reduction, and position of immobilization), as well as reporting that pre-reduction traction is falling out of favor among many orthopedic surgeons [17,18].

Treatment of AVN and secondary deformity caused by AVN

Once AVN in DDH is established, treatment options concentrate mainly on improving the biomechanics of the proximal femur [5]. The most common types of deformity following ischemic necrosis are femoral neck shortening, overgrowth of the greater trochanter, and significant varus deformation [19]. A surgical intervention has to deal with these deformities in order to restore the normal joint kinematics and biomechanics [10]. Whether the physes are open or closed is a significant factor that has to be considered before choosing the correct osteotomy. A wide variety of proximal femoral osteotomies have been reported in the literature. Hasler and Morscher describe use of 2 parallel osteotomies of the femur, at the upper and lower border of the femoral neck, followed by distalization of the greater trochanter in 37 patients (with short femoral neck and overgrowth of greater trochanter) with good results in 32 [20]. Buess and Morscher described 3 osteotomies (one at the greater trochanter, a second osteotomy at the proximal femoral neck, and a third oblique osteotomy at the distal femoral neck) in 16 operated hips, with satisfactory results in 14, in order to lengthen the femoral neck and transfer the greater trochanter [21]. Garrido et al. reported a distal and lateral transfer of the grater trochanter in 10 patients aged 4–13 years with coxa vara and concluded that this technique is a simple and produces good results [22]. Bartonicek et al. performed valgus intertrochanteric osteotomy in 6 patients (average age, 17 years) for post-traumatic partial necrosis of the femoral head, and reported subjective and objective improvement confirmed by MRI in all 6 patients [23]. Bayhan et al. performed proximal femoral valgus osteotomy in 48 hips of children with coxa vara and spondyloepiphyseal dysplasia and concluded that is an effective treatment that can improve hip pain and range of motion, in addition to sagittal spinopelvic alignment [24]. The literature contains many reports describing treatment of secondary deformity of AVN, but few studies have described the treatment strategy of AVN in DDH [22–24].

We treated our patient with a relatively simple shortening valgus and derotation osteotomy and acetabuloplasty of the pelvis with bone graft simultaneously in order to shift the femoral head necrotic-segment from the weight-bearing zone underneath the acetabulum to another area, to increase the joint congruity and to provide an adequate coverage of the shifted femoral head. Valgus osteotomy can also distalize the greater trochanter and thereby lengthens the lateral level arm of the abductors, without performing an isolated trochanteric osteotomy. We chose Dega osteotomy among other pelvic osteotomies, after taking into account the age of our patient (open growth plates and therefore open Y-shaped epiphyseal plate) and the fact that we especially wanted to improve the lateral coverage of the femoral head. Since lateral coverage was not severely decreased, we chose to proceed with a single pelvic osteotomy rather than a periacetabular osteotomy with higher correction potential. The possible problem of increased intra-articular pressure was assessed by shortening of the femur (18-mm shortening osteotomy) in combination with the valgus osteotomy. The leg-shortening cannot be fully addressed at this stage because of the possibly increased intra-articular pressure, and it has to be treated at a later stage, probably with contralateral epiphysiodesis according to the amount of limb-lengthening discrepancy. Kim et al. performed a valgus femoral osteotomy in 25 patients in the late fragmentation stage of severe Legg-Calve-Perthes disease, and 7 patients also required additional pelvic osteotomies. They reported that all femoral head roundness measurements improved, suggesting valgus femoral osteotomy helps a deformed femoral head to remodel in order to fit the acetabulum [25].

In our case, hip function and joint congruency also improved at first, but after 1 year, the pre-existing collapse of the femoral head resulted in the formation of a bump in the femoral head/neck junction, which aggravated the pain of our patient and required additional intervention. This possible bump formation after valgus proximal femoral osteotomy was also reported by Kim Yong et al., and is especially likely if the necrosis of the femoral head is too wide [26]. Clohisy et al. investigated the deformities of the proximal femur after re-orientation acetabular osteotomies, finding that proximal femoral deformities were present in 92.6% of the hips treated for acetabular dysplasia, with 73.1% of the hips having an abnormal head-neck junction or α-angle and 72% having an aspheric femoral head [27]. Myers et al. reported that a secondary impingement syndrome can occur after periacetabular osteotomy, characterized by abutment of the femoral head or head-neck junction on the anterior rim of the properly aligned acetabulum, with limitations of internal rotation and groin pain [28].

The resection of this bump simultaneously with metal removal through a minimally invasive hip arthroscopy procedure in this age group (6 years old) is a new possible treatment option.

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Our patient did not have any post-operative complications and she had a rapid recovery. While remodeling the bone and resecting the bump with a burr, the edge of the growth plate became visible and the resection could be safely performed without damaging the visible growth plate.

To the best of our knowledge, this is the first report of arthroscopically resected CAM after a valgus proximal femur osteotomy in a young child. Hip arthroscopy in children is mainly used to aid reduction of a dislocated hip, in the management of septic arthritis, and in femoral acetabular impingement in adolescents [29]. We believe that hip arthroscopy in children is a new growing field that can be extremely helpful with indications that will continue to evolve the near future. It adds a new option for treating sequelae of hip deformities, in addition to the other well-known osteotomy procedures.

Conclusions

AVN of the femoral head resulting from DDH treatment is a serious complication leading to significant alterations in the hip joint, mainly characterized by limping and limited motion caused by joint incongruency, coxa vara, overgrowth of the greater trochanter, short femoral neck, and limb-length discrepancy. A shortening valgus osteotomy (with optional derotation osteotomy) combined with pelvic osteotomy to achieve a good coverage of the shifted femoral head is a reasonable option for this severe situation, especially in patients with further growth remaining, and it can improve joint kinematics and biomechanics. At the time of metal removal, hip arthroscopy can be an additional useful tool to improve joint congruency, while the growth plate can be resected during the bony remodeling.

Conflicts of interest

None.

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