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A Single Approach to Arthroscopic Reduction and Debridement for Developmental Dislocation of the Hip in 12 Infants

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Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
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Background: Developmental dislocation of the hip (DDH) results in osteoarthritis in infants and children. This study aimed to investigate the effects of a single approach to arthroscopic reduction and debridement on clinical outcome in 12 infants with DDH.

Material/Methods: Twelve infants with irreducible DDH underwent single approach arthroscopic reduction and debridement followed by the use of a frog-leg position plaster cast with fixed flexion and abduction of the hips combined with external fixation for 6–8 weeks. Magnetic resonance imaging (MRI) or plain X-ray images were analyzed. Intra-articular obstructive factors for reduction were evaluated. The safety angle, medialization rate of the femoral head, and the acetabular angle were measured before and after arthroscopic reduction.

Results: Imaging showed that the signs of DDH were significantly improved following arthroscopic reduction. Obstructive factors included hypertrophy of the round ligament, fibrous tissue and fat in the acetabular base, arthrocapsular constriction, and varus deformity of the hip. The safety angle was significantly increased following arthroscopic reduction (53.5°) compared with the safety angle before treatment (18.5°) ($p<0.05$). Medialization of the femoral head was significantly increased (127%) compared with that before treatment (72%) ($p<0.05$). Arthroscopic reduction significantly reduced the acetabular angle (25°) compared with that before treatment (37.5°) ($p<0.05$).

Conclusions: Single approach arthroscopic reduction and debridement was an effective method for treating DDH that significantly improved the medialization rate of the femoral head, acetabular angle, and the outcome of external fixation when a plaster cast was used with fixed flexion and abduction of the hips.

MeSH Keywords: **Arthroscopy • Hip Dislocation, Congenital • Osteoarthritis, Hip**

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Background

Developmental dislocation of the hip (DDH) is one of the most common causes of osteoarthritis of the hip in infants and children [1,2]. Clinically, early diagnosis and treatment for DDH are crucial to reducing the risk of disability [3]. For infants and young children, treatment with a spica cast or a Pavlik harness in the first week of life is effective for most patients [4]. The success rate for early treatment with the Pavlik harness in DDH is >90% [5]. The Bernese periacetabular osteotomy (PAO) method is considered to be an effective treatment for symptomatic DDH in the early stage, which improves hip stability and repairs biomechanical abnormalities [6,7]. However, particularly for patients in developing countries, there may be a delay, or they may miss the optimal treatment period for PAO.

The open reduction approach to the treatment of DDH is usually combined with femoral osteotomy and acetabuloplasty and is the standard method for treating DDH following failed closed reduction [8,9]. However, there are several serious complications following open reduction, including avascular necrosis (AVN) of the femoral head, which may adversely affect the outcome for patients with DDH [10,11]. For infants and young children who miss the early opportunity for treatment, open reduction should be performed, but optimal approaches to the surgical procedures in open reduction for DDH remain controversial [12].

Recently, technological improvements in arthroscopic reduction have resulted in minimally invasive surgical treatment for open reduction, which has been extensively used for the treatment of DDH [13,14]. The arthroscopic reduction strategy is characterized by the identification of obstacles to reduction [15,16]. However, some complications arise during the surgical management of DDH. To reduce the complications and to allow for treatment of DDH in the early stage, we proposed that a single approach to arthroscopic reduction and debridement might result in clinically improved outcomes in infants. Therefore, this study aimed to investigate the therapeutic effects of a single approach arthroscopic reduction and debridement on clinical outcome in 12 infants with DDH and the indications for treatment.

Material and Methods

Patients

This study included 12 infants who were diagnosed as the irreducible developmental dislocation of the hip (DDH) and who underwent arthroscopic reduction from January 2014 to December 2016. The patients with DDH included two male infants and 10 female infants, with a mean age of 14 months (range, 10–20 months). A total of 13 hips in 12 patients were included in this study analysis. Eleven patients had a unilateral hip dislocation, and one patient had bilateral hip dislocation with one side that did not require arthroscopic reduction. Osteoarthritis of the hip joint was graded by the Tönnis classification and included three cases of Grade 2, six cases of Grade 3, and three cases of Grade 4 osteoarthritis. All patients had imaging with plain X-radiographs, and magnetic resonance imaging (MRI), which were reported by two experienced radiologists.

The study inclusion criteria were patients who suffered from the failed closed reduction, with an MRI scan that showed an inverted labrum or intra-acetabular soft tissues. Study exclusion criteria were patients with hip infections or immune system disorders, or a previous history of hip surgery. This study was approved by the Ethics Committee of the Beijing Jishuitan Hospital, Beijing, China. All the guardians of patients signed the written informed consent and approved participation in this study.

Surgical procedures

All patients with DDH underwent a single approach arthroscopic reduction to treat the dislocated hips. The surgical procedures were conducted under the general anesthesia, with the patient in the supine position, and were performed by an experienced surgeon who was familiar with the arthroscopic hip reduction procedure. Arthrography was performed before surgery to evaluate the position of the femoral head and the other anatomical joint structures. The single approach arthroscopic reduction surgery was conducted as previously reported [4]. The surgical procedures are shown in Figure 1.

Postoperative treatment and evaluations

Between six and eight weeks following external fixation, a plaster cast with fixed flexion and abduction of the hips (frog-leg position) was used for 2–3 months. The MRI or plain X-ray images were analyzed. The medialization rate of the femoral head was noted [17], and the femoral head necrosis, the acetabular index, and dislocation levels were measured before and after arthroscopic reduction, and the Tönnis classification was used [18]. Other complications, including hematoma and infection, neurovascular injury, and pressure sores, were recorded following arthroscopic reduction. Finally, the gait, hip range of motion, length of the lower limbs, and the Trendelenburg sign were evaluated at the last follow-up for each patient.

Statistical analysis

Data were presented as the mean ± standard deviation (SD) and analyzed using SPSS version 19.0 software (SPSS Inc.,

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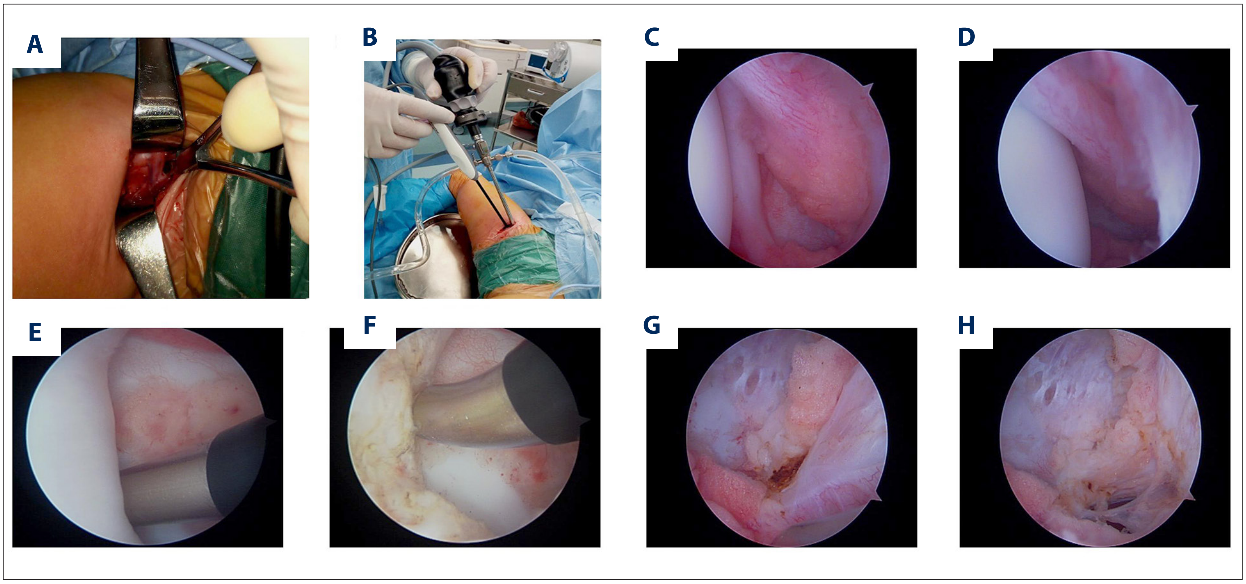

Figure 1. The surgical procedure for the single approach arthroscopic reduction and debridement of fibrous and adipose tissue at the base of the acetabulum. (**A**) Cutting of the adductor muscle and iliopsoas muscle to identify the medial circumflex femoral artery. (**B**) Using the single approach, the guide and knife could be inserted at the same time. (**C, D**) Hypertrophic round ligaments are shown that obstruct the reduction. (**E, F**) Increased inverted labrum, two-thirds of which was cut with internal integrity. (**G, H**) Debridement of the fibrous and adipose tissues at the base of the acetabulum.

Chicago, IL, USA). Student's t-test was used to compare the posterior safety angle and the medialization rate of the femoral head before and after the arthroscopic reduction. The acetabular angle before the operation and the last follow-up were also compared using Student's t-test. A P-value <0.05 was considered to be statistically significant.

Results

The single approach to arthroscopic reduction and debridement resulted in an improved reduction of developmental dislocation of the hip (DDH)

Following debridement of the fibrous and adipose tissues at the base of the acetabulum, the reduction surgery was conducted under the arthroscopy. According to the plain X-ray and magnetic resonance imaging (MRI) findings for safety angle, reduction status, and external fixation using the frog-leg position plaster cast, DDH was significantly improved following arthroscopic reduction (Figures 2, 3).

Intra-articular obstructive factors for arthroscopic reduction

In this study, the patients were followed-up at 2 weeks, 6 weeks, 12 weeks, 6 months, 12 months, 18 months, 24 months, 30 months, and 36 months following surgery. Because some patients did not attend all the follow-up sessions, the length of follow-up ranged from 18–36 months (mean, 26 months). At the last follow-up, none of the 12 patients reported pain, none had limited activity or limb shortening, and all had a negative Trendelenburg sign. The findings also showed that there were several intra-articular obstructive factors for reduction, including hypertrophic round ligament, acetabular fibro-fatty mass, arthrocapsular constriction, and varus deformity of the hip (Table 1).

The single approach to arthroscopic reduction increased the safety angle and medialization rate of the femoral head in patients with DDH

The DDH parameter of the safety angle was significantly increased (53.5°; range, 45–60°) following arthroscopic reduction when compared with the safety angle before treatment (18.5°; range, 10–30°) ($p<0.05$) (Figure 4A). The medialization rate of the femoral head was also significantly increased after the arthroscopic reduction treatment (127%; range, 74–173%) compared with that before treatment (72%; range, 34–128%) ($p<0.05$) (Figure 4B). Also, at six weeks after arthroscopic reduction, the medialization rate of the femoral head (141%; range, 85–176%) was significantly improved when compared with that at day 0 following the arthroscopic reduction (127%; range, 74–173%).

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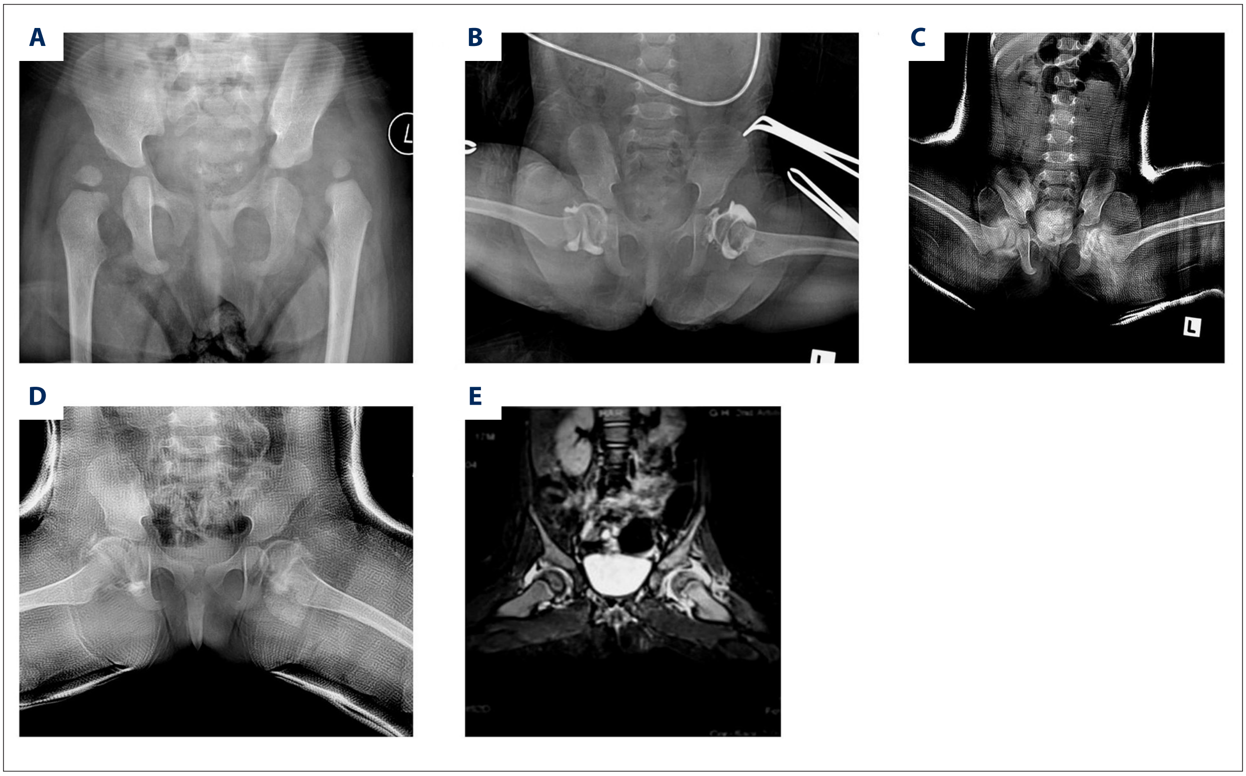

Figure 2. A female infant aged 14 months with developmental dislocation of the hip (DDH). (**A**) Bilateral dislocation of the hip before the operation. (**B**) Labrum varus following the removal of the adductor muscle and iliopsoas muscle. (**C**) External fixation using the frog-leg plaster cast with fixed flexion and abduction of the hips following the arthroscopic debridement. (**D, E**) Second-stage frog-leg cast external fixation at six weeks following the arthroscopic reduction on plain X-ray and magnetic resonance imaging (MRI).

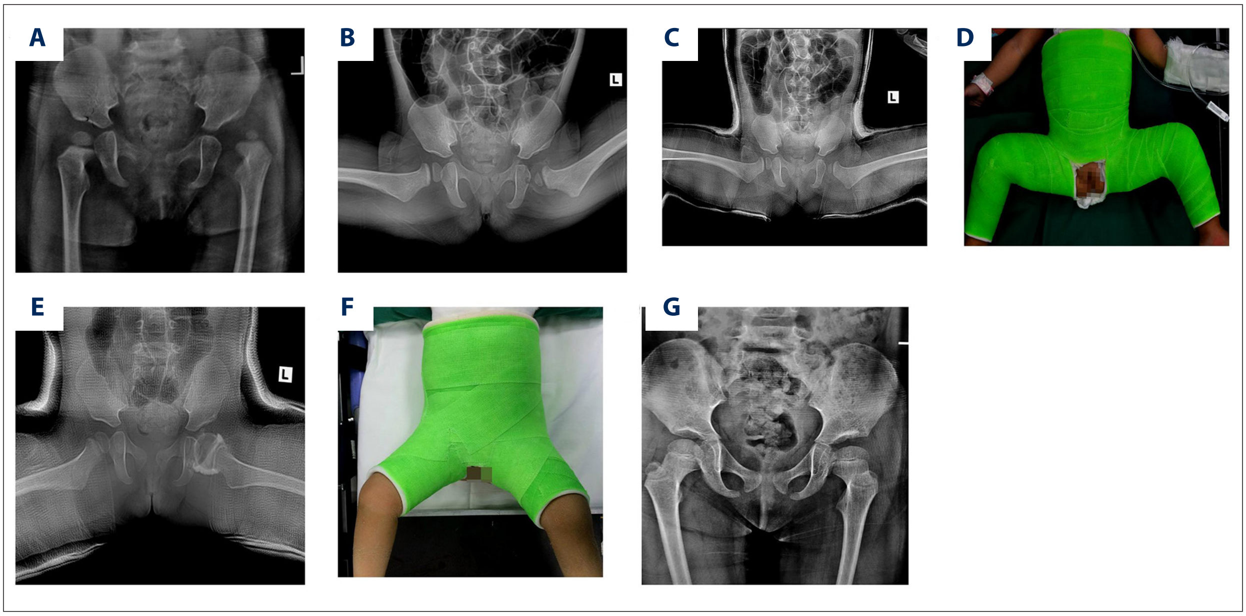

Figure 3. A female infant aged 14 months with developmental dislocation of the hip (DDH). (**A**) Unilateral left side dislocation. (**B**) Image after the arthroscopic debridement. (**C, D**) The first-stage of external fixation using the frog-leg cast after arthroscopic debridement. (**E, F**) The second-stage of external fixation using the frog-leg cast following the arthroscopic debridement. (**G**) Image at two and a half years using X-ray plain scan.

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Table 1. Intra-articular obstructive factors in 12 infants who underwent the single approach arthroscopic reduction and debridement for developmental dislocation of the hip (DDH).

Patients (gender)	Age (months)	Left/ right	Tönnis grading	Early phase treatment	Hypertrophic transverse acetabular ligament	Hypertrophic round ligament	Fibro-fatty mass	Arthrocapsular constriction	Varus deformity of the hip
1 (F)	17	L	3	No	–	+	+	+	+
2 (F)	14	L	3	No	–	+	+	–	+
3 (F)	20	R	3	No	–	+	+	+	+
4 (F)	14	L	2	No	–	+	+	–	–
5 (M)	10	R*	2*	No					
		L	4	No	–	+	+	+	+
6 (F)	11	R	4	No	–	–	+	+	+
7 (M)	11	L	2	Pavlik	–	+	+	–	–
8 (F)	12	L	2	No	–	+	+	–	–
9 (F)	17	R	3	No	–	+	+	+	+
10 (F)	15	L	3	No	–	+	+	–	+
11 (F)	13	L	3	No	–	+	+	–	+
12 (F)	16	R	4	No	–	–	+	+	+

F – Female; M – Male; L – left; R – right. * Represents no requirement for endoscopic reduction.

The single approach arthroscopic reduction reduced the acetabular angle in patients with DDH

The single approach arthroscopic reduction significantly decreased the acetabular angle after treatment (25°; range, 19–40°) compared with that before treatment (37.5°; range, 30–52°) ($p<0.05$) (Figure 4C).

Discussion

The treatment of dislocation of the hip depends on the age of the patient, the anatomical structures of the proximal femur, the degree of dislocation, and whether or not there is acetabular dysplasia when the acetabulum is too shallow to provide coverage of the femoral head [4,19]. Closed reduction methods have previously been used routinely to treat the dislocated hips in the first year of life of infants, but if this method is not effective, other treatments must be conducted [20]. Although open reduction is considered to be a standard approach for treating developmental dislocation of the hip (DDH), arthroscopic reduction has been used more recently. In the present preliminary study, the findings in 12 infants with DDH supported the effectiveness of the single approach to arthroscopic reduction and debridement. In this study, follow-up evaluated the long-term clinical outcomes.

According to the findings from previously published studies, there are several surgical methods for arthroscopic hip surgery [21,22]. In this study, the single approach to arthroscopic reduction was used to treat DDH with an anterior portal and anterolateral portal under the assistance of a Kirschner wire to position the hip joints. Previous studies have investigated dual approaches to determine the anatomical structures of the hip joint [13,23]. However, the single approach arthroscopic reduction allowed examination of the intra-articular anatomical structures of the hip joint and facilitated debridement of the fibrous adipose tissues at the base of the acetabulum in all patients with DDH. Also, there was no limitation in the use of surgical instruments, which saved time during surgery.

The main intra-articular obstacles to hip reduction in DDH in this study included hypertrophy of the round ligament, fibro-fatty mass, capsular constriction, and varus deformity of the hip, which

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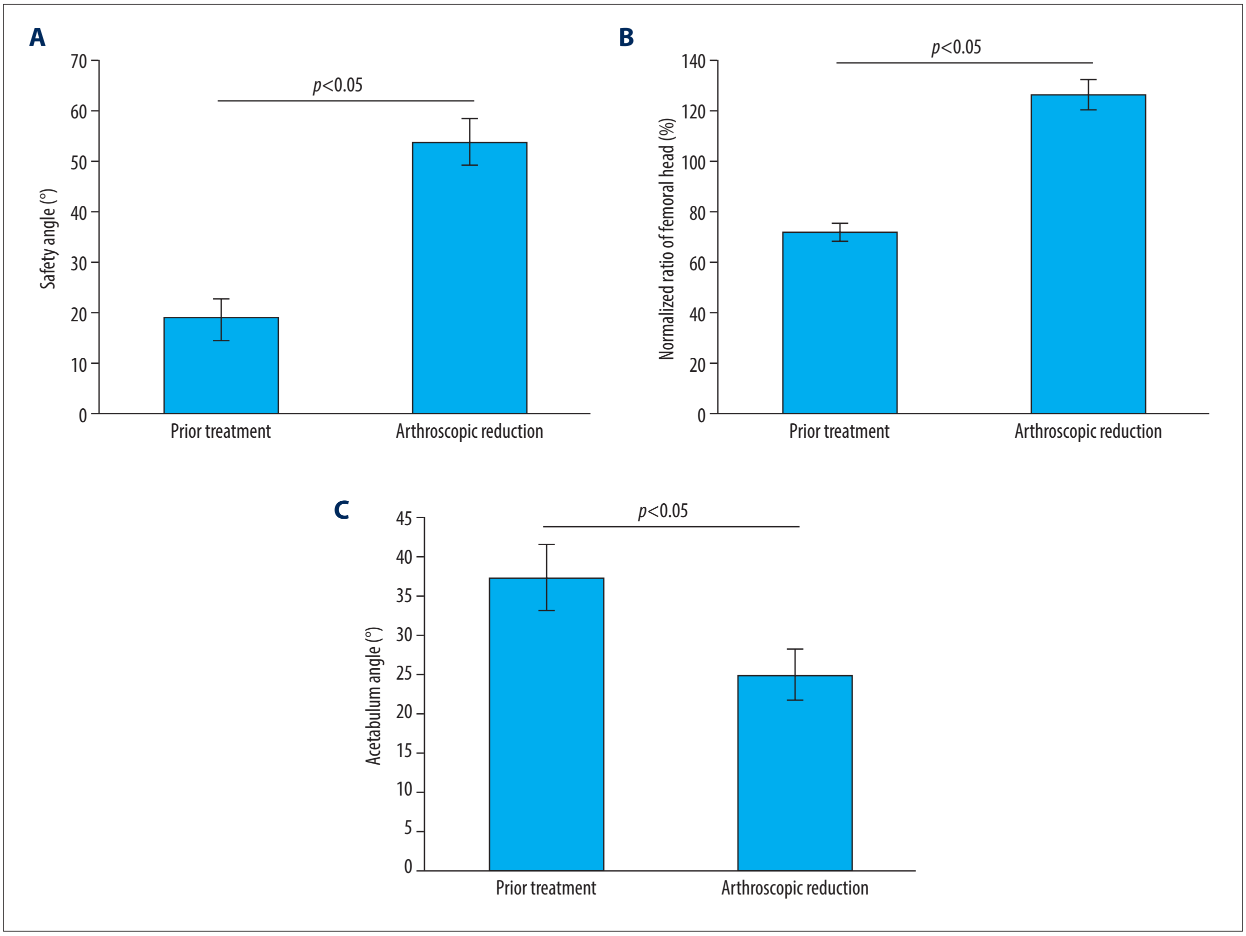

Figure 4. Evaluation for the safety angle, medialization rate of the femoral head, and acetabular angle in patients with developmental dislocation of the hip (DDH). (**A**) Statistical analysis for the safety angle. (**B**) Statistical analysis for the medialization rate of the femoral head. (**C**) Statistical analysis for the acetabular angle. $P<0.05$ represents a significant difference.

have also been reported in previous studies [4,13,23]. The acetabular ligament is considered to be the key obstacle for hip reduction [24]. Guille et al. [25] showed that removing the acetabular ligament was important for complete hip reduction. Therefore, in our study, we cut the acetabular ligament in all patients with DDH. Because the acetabular labrum could also hinder reduction [26] and should always be removed or incised [27], in this study, eight out of 12 cases underwent radial incision of the acetabular labrum on the single approach arthroscopic reduction. Due to the structural importance of the acetabular labrum to the prevention of joint degeneration [28], we did not completely remove this structure. However, the findings from some previously published studies do not support the removal or sectioning of the acetabular labrum [29,30]. In the present study, two out of 12 cases showed acetabular dysplasia where the acetabulum was too shallow to provide coverage of the femoral head, resulting in joint instability that required treatment with a second operation.

Also, several risk factors can influence the clinical outcome following hip joint reduction, including avascular necrosis (AVN) of the femoral head, which has a prevalence of between 0–69%, and is an important index for evaluating successful reduction following treatment [31,32]. In the present study, only one out of 12 patients (8.33%) was diagnosed with a MacEwen type I AVN, or Tönnis Grade 4 osteoarthritis. However, during the two-year follow-up, the AVN was repaired satisfactorily. The MacEwen type I AVN might have been caused by several factors, including the release of the adductor and iliopsoas muscles before surgery, or intra-articular debridement resulting in injury to the blood supply, or due to the position of the hips during external fixation while in the cast.

In the present study, the single approach to arthroscopic reduction significantly improved the clinical and anatomical parameters of patients with DDH, including the safety angle, the medialization rate of the femoral head, and the acetabular angle. Our results indicated that the safety angle and the medialization rate of the femoral head were significantly increased following arthroscopic reduction when compared with these parameters before treatment. Also, arthroscopic reduction

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significantly decreased the acetabular angle after treatment compared with before treatment. These findings are consistent with those from a previously reported case series that showed the use of an arthroscopic technique combined with open psoas tenotomy and arthroscopic reduction could eliminate the intra-articular structures that impede reduction of the femoral head in infants with DDH [33]. In this previous study, the ligaments and tissues in the acetabulum were controlled arthroscopically, and a successful outcome at short-term follow-up was demonstrated [33].

This study had several limitations. The study included a small sample size of 12 patients, and the follow-up period was short. Also, the optimal approaches for arthroscopic reduction, including the best strategy for treating an inverted acetabular labrum, were not investigated.

Conclusions

The findings from this study showed that single approach arthroscopic reduction and debridement was an effective method for treating developmental dislocation of the hip (DDH), which significantly improved the safety angle, medialization rate of the femoral head, acetabular angle, and improved the safety of external fixation using the frog-leg plaster cast. Also, compared with the dual approach to arthroscopic reduction, this single approach was relatively simple to perform.

Conflict of interest

None.

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