Traumatic hip dislocation in children
Nguyen Ngoc Hung

The aim of this study was to evaluate the outcomes of reduction in the treatment of traumatic posterior hip dislocation in children. Data of 22 pediatric patients (22 hips) with traumatic hip dislocation from January 1995 to December 2007 were analyzed. The clinical evaluation focused on symptoms, physical findings, and range of motion. Radiographs identified the type of hip dislocation. The hip dislocation classification was based on Thompson and Epstein. The reduction procedure was performed according to three variants: variant 1, closed reduction; variant 2, release of the adductor longus, lengthening of the psoas tendon, and insertion of a Kirschner wire through the femoral head into the acetabulum; and variant 3, removal of the soft-tissue interposition of the hip. After reduction, radiography was used to determine whether the hip is concentrical and to check whether any other injuries might have been caused after manipulation. There were six females (27.3%) and 16 males (72.7%) in this study. All had type I posterior dislocation of the hip. The ages of the patients at diagnosis ranged from 3 years, 2 months to 9 years, 10 months. The reduction procedure was performed according to variant 1 in 16, variant 2 in five, and variant 3 in one. We attained excellent results in eight hips (36.4%), good results in seven hips (31.8%), fair results in four hips (18.2%), and poor results in three hips (13.6%). There was avascular necrosis in three hips (13.6%), coxa magna in two hips (9.1%), deficient limb of 2 cm in two hips (9.1%), and a limp in two hips (9.1%). The hip scores were 82.4 points on average (range 62–100). Children with traumatic hip dislocation should undergo reduction as soon as possible. If the interval from injury to reduction exceeds 3 weeks, we suggest that the surgeon release the adductor longus, lengthen the psoas tendon, and insert a Kirschner wire. This simple and safe surgical procedure results in marked improvement in hip function and prevents complications later. J Pediatr Orthop B 21:542–551 © 2012 Wolters Kluwer Health | Lippincott Williams & Wilkins.


Keywords: femoral head necrosis, hip dislocation, hip fractures, multiple injuries, osteoarthritis

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Introduction

Traumatic hip dislocation in childhood is rare. Several small series of this condition have been reported [1–3]. The dislocation can be caused by major trauma, but can also occur after a minor injury. There is usually a favorable outcome after expedient reduction, although avascular necrosis (AVN), traumatic arthritis, myositis ossificans, joint instability, and osteonecrosis of the femoral head [4] can occur. Reduction is usually easy to achieve, but labral, capsule, and/or osteochondral fragment interposition may prevent concentric reduction [5], and may require surgery to achieve anatomic reduction. We analyzed a retrospective series of 22 traumatic hip dislocations in skeletally immature patients. We specifically reviewed the types of dislocations, the magnitude of inciting trauma, treatments, and clinical and radiologic outcomes.

The aim of this study was to evaluate the outcomes of reduction in the treatment of traumatic posterior hip dislocation in children.

Materials and methods

A retrospective study was carried out to evaluate the results of reductor procedures performed from January 1995 to December 2007 in 24 pediatric patients (24 hips) with traumatic hip dislocation. Two patients (two hips) were excluded from the study because of insufficient follow-up. The remaining 22 patients (22 hips) were included in this study.

There were 22 patients; 15 patients ranged in age from 3 to 6 years and seven patients ranged in age from 7 to 10 years. A fall or a trivial fall was the cause of trauma in nine patients; a traffic accident was the cause of trauma in four patients; ‘struck on the back’ was the cause of trauma in two patients; and injury while playing football was the cause of trauma in seven patients.

Preoperatively, information was obtained on the following: (a) age and sex of the patient; (b) type of dislocation; (c) type of trauma; (d) time from injury to reduction; (e) type of treatment; (f) duration of immobilization; (g) associated injuries; and (h) complications. The clinical evaluation focused on the symptoms, physical findings, and range of motion. Clinical data and all imaging studies were reviewed, including radiographs, computed tomography, MRI, and bone-scan examinations. Special attention was paid on the assessment of heterotopic ossification, AVN, and epiphyseal hypertrophy (coxa magna 2 mm vs. the opposite side).

The trauma-causing dislocation was classified into three types: mild injury caused by running, tripping, or falling; moderate injury as a result of excessive speed (cycling or
skiing) or excessive force (football); and severe injury caused by a high-energy impact or crushing. The children were then examined to assess the function and development of the hip. A clinical assessment was carried out for symptoms, range of movement, function, and disability of the hips.

Radiographs of the hip were taken in both the anteroposterior and the frog-leg positions, and the presence of coxa magna, irregularity of the femoral head, and the presence of arthritic changes in the hip were recorded.

Dislocations were divided into anterior and posterior groups. The posterior group was subdivided into five types according to Thompson and Epstein [6].

One surgeon (the author) performed all the reduction procedures.

**Reduction procedure**

For each patient, we use one of three variants of the reduction procedure, as detailed below.

**Variant 1**

Variant 1 (V1) is performed on any patient who has a time interval of less than or equal to 3 weeks between injury and reduction. Emergent closed reduction for traumatic hip dislocation is indicated for a dislocation with or without a neurologic deficit when no associated fracture is present.

*Technique.* General anesthesia is preferred; however, more often, closed reduction under sedation is performed in the emergency room. In the Allis method [7], the surgeon stands on the stretcher. By pulling just below the knee, he/she applies traction in line with the femur. The assistant applies counter traction by pushing downward on both anterior superior iliac spines. With steady increasing traction, the hip is flexed to 70°. Adduction and gentle internal and external rotation of the hip allow the hip to pass across the lip of the acetabulum. A lateral-directed force may also help. This can be applied with an assistant’s hands on the upper thigh or with a sheet wrapped around the ipsilateral groin and pulled in a lateral and superior direction. Stability should be checked.

After reduction, radiography is used to identify whether the hip is concentrical, and to check whether any other injuries might have been caused after manipulation. The patients are immobilized in plaster hip spica immediately with hip neutral extension (0°), abduction of about 40–45°, and internal rotation of about 20–30°.

If the hip fails to reduce after two or three attempts at a closed reduction, an open reduction should be performed according to variant 2 (V2).

**Variant 2**

If the hip fails to reduce after two or three attempts at a closed reduction, and the patient has a time interval of greater than 3 weeks between injury and reduction, V2 is performed. We release the adductor longus muscle at its attachment and lengthen the psoas tendon.

With the patient supine, the affected extremity is prepared and draped. With the hip flexed and in unforced abduction, the neurovascular bundle and the lateral borders of the adductor longus muscle are identified. A longitudinal 6-cm incision is made on the lateral aspect of the thigh, in line with the lateral borders of the adductor longus muscle, 1 cm below the pubis (cf. Fig. 1a). The skin and subcutaneous tissues is incised down to the deep fascia and the fascia lateral borders of the adductor longus muscle are incised. The anterior branch of the obturator nerve is followed proximally to its entrance into the thigh.

**Fig. 1**

(a) Incision is in line with the lateral borders of the adductor longus muscle, 1 cm below the pubis, longitudinal 6-cm incision on the lateral aspect of the thigh. (b) Release adductor longus muscle, and lengthening psoas tendon. (c) The hip was held in place with a 3-mm Kirschner wire through the femoral head into the acetabulum.

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under the pectineus muscle. The neurovascular bundle is gently retracted superiorly. Keeping the anterior branch of the obturator nerve in sight, the sheath overlaying the pectineus muscle is opened, and its superior and inferior borders are identified. The interval between the pectineus muscle and the femoral neurovascular bundle is identified and bluntly dissected. The iliopsoas tendon is isolated in the inferior aspect of the wound, the iliopsoas tendon is exposed, and it is lengthened by plastic Z (cf. Fig. 1b). Then manipulation of the reduction is performed. After reduction, radiography is used to identify whether the hip is concentrical and to check whether any other injuries might have been caused after manipulation. The wound is closed in layers. The hip is held in place with hip neutral extension (0°), an abduction of about 40–45°, internal rotation of about 20–30°, and an insertion of a 3-mm Kirschner wire (K-wire) through the femoral head into the acetabulum (cf. Fig. 1c). The patients are immobilized in plaster hip spica immediately.

**Variant 3**

If the hip fails to reduce according to V2, and the patient has a time interval of greater than 6 weeks between injury and reduction, a posterior approach is used to avoid further devascularization of the femoral head and special attention is paid to the visualization and protection of the sciatic nerve. To perform identify the redundant posterior capsule with the head of the femur was proximal to the upper edge of the acetabulum, the sciatic nerve. The capsular hip is exposed to identify the articular cartilage of the head of the femur, ligamentum teres, whether the acetabular cavity is extremely shallow, and acetabular labrum. The redundant posterior capsule is partially resected. Parts of the very thick anteroinferior capsule are also removed and psoas insertions are detached. If the acetabular cavity appears to be very shallow, it is removed with a sharp spoon. The acetabulum is cleared of all the scar tissue and tom labral fragments. The head of the femur is reduced into the acetabulum by traction in flexion and counter traction. The capsule is united by catgut, the lower portion being left open for drainage [8]. The insertion of a 3-mm K-wire is performed through the femoral head into the acetabulum. The capsular hip is closed with nonabsorbable sutures. The wound is closed in layers. The patients are immobilized in plaster hip spica immediately.

**Aftercare**

The K-wire was removed at 3–4 weeks. The time of removal of the plaster hip spicas varied: for patients who underwent reduction according to V1, it was done in 6 weeks; for V2 in 9 weeks; and for variant 3 (V3) in 12 weeks. After removing the plaster, radiographs of the hip were taken for all patients. After removal of the plaster, each patient underwent a period of crutch-protected non-weight-bearing: for patient who underwent reduction according to V1, this time period was 6 months; for V2 it was 9 months; and for V3, it was 12 months. Following these non-weight-bearing periods, a radiograph of the hip was taken for all patients.

We evaluated the patients independently every 6 months thereafter.

After reduction, each patient’s medical record was reviewed, focusing on the symptoms, physical findings, and radiographs of the hip. The clinical evaluation focused on range of motion, the presence of pain and/or limp, and the ability to squat. A Harris hip score [5] was also calculated for each patient at 6 months after dislocation and at the final follow-up. Leg lengths were measured from the anterior superior iliac spine to the medial malleolus.

The radiographic evaluation included the prereducive and the most recent films obtained. AVN was graded according to Barquet [9] [type I (normal), type II (minimal coxa magna, no coxa breva, no acetabular changes), type III (coxa magna, coxa breva, femoral neck widening, varus/valgus angulation of the neck, enlarged acetabulum), type IV (coxa magna with flattening of the femoral head, coxa breva, varus or valgus alignment, and acetabular deformity), and type V (changes similar to AVN in adults, no growth disturbance)].

The results were graded as excellent, good, fair, or poor according to Garrett et al. [10]. An excellent result meant no pain, a full range of hip motion, and no limp. A good result indicated some pain that was not disabling, 50% of normal hip motion, and a slight limp. A fair result meant some pain that was not disabling, 50% of normal hip motion, and a moderate limp. A poor result indicated disabling pain, marked limitation of hip motion, and abduction or adduction deformity.

**Results**

From August 1995 to December 2007, 22 patients (22 hips) were treated for traumatic hip dislocation. Of the 22 dislocations in our study, 12 (54.5%) occurred on the right and 10 (45.5%) on the left side. Sixteen (72.7%) were in males, and six (27.3%) in females. The ages of the patients at the time of diagnosis ranged from 3 years, 2 months to 9 years, 10 months. There were two age ranges during which dislocation of the hip appeared to be more frequent, with 15 of 22 patients (68.2%) ranging in age between 3 and 6 years, and 7 of 22 patients (31.8%) ranging in age between 7 and 10 years. All patients had Thompson and Epstein [6] type I posterior dislocations of the hip without any associated fracture.

There were two age groups: group I (3–6 years old), including 15 patients, group II (6–10 years old), including seven patients. Ten of 22 patients were between 6 and 7 years of age. Eight of 22 patients were younger than 6
years of age and the remaining 14 patients were older than 6 years of age.

**Type of injury and type of reduction in 22 children**

Injury was caused by a fall and a trivial fall in nine patients; six of nine patients underwent reduction according to V1 and the remaining three underwent reduction according to V2.

Injury had occurred because of a traffic accident in four patients; two of four patients underwent reduction according to V1 and the remaining two underwent reduction according to V2.

Two patients had been struck on the back; these patients underwent reduction according to V1.

Injury was caused while playing football in seven patients; six of seven patients underwent reduction according to V1 and the remaining one patient underwent reduction according to V3.

No correction of type of injury and type of reduction.

Information on the mechanism of injury in all patients was not specifically requested in the original questionnaire, but this aspect was thoroughly explored at the time of the final report.

The cause of the dislocation was known for all patients: four occurred in automobile accidents, nine in falls of various types, two patients had been struck on the back, and seven patients developed an injury while playing football.

All patients had traumatic dislocation of the hip and even patients have accident without other injuries involved.

**Time of interval between the injury and the reduction procedure**

**Time interval between injury and reduction**

The time interval between injury and reduction was 1–3 weeks in 16 patients [16 (≤ 24 h in six patients, >24 h–3 weeks in 10 patients)]; 3 to less than or equal to 6 weeks in two patients (4 weeks in one patient and 5 weeks in one patient); and more than 6 weeks in four patients (9 weeks in one patient, 10 weeks in one patient, 13 weeks in one patient, and 19 months in one patient).

Sixteen patients underwent reduction according to V1; five patients underwent reduction according to V2; and one patient underwent reduction according to V3 (Tables 1 and 2).

**Complications**

AVN was present in three patients; coxa magna in two patients (2 cm in one patient, 3 cm in the other); and deficient limbs in two patients (2 cm in one patient, 3 cm in the other). Two patients had a limp. There was no correlation between the type of injury and complications.

Three of the 22 patients (patient numbers 6, 16, and 18) have been followed to skeletal maturity, and two of the three showed abnormal results: one has deficient limb 2 cm (number 6) and one has a limp (number 18), whereas number 16 is normal.

**Discussion**

Traumatic dislocation of the hip is rare in children and can occur as a result of minor injuries sustained while playing or engaged in sporting activities. This was the case in seven of our children (31.8%), who had low-energy injuries. Barquet [9], Hamilton and Broughton [2], and Rieger et al. [11] also found that the magnitude of force producing the injury increased with the age of the patient.

We believe that low-energy trauma can cause dislocations in younger patients because their periarticular structures are more flexible. Flexibility of the periarticular structures may also explain the absence of bony lesions of the acetabulum or the femoral head, in contrast to adults, in whom an acetabular fracture is a frequent concomitant injury with traumatic dislocation of the hip. However, all patients with traumatic dislocation of the hip and even patients who were involved in an accident should undergo a careful full-body examination to identify other injuries involved.

Several authors [2, 11, 12] have classified traumatic hip dislocation into two groups according to the age at the time of injury. The first group included children younger than 10 years of age, in whom the injury was associated with a relatively minor trauma, such as a simple fall. The second group included children older than 10 years of age in whom hip dislocation was associated with a more severe or forceful injury, such as injury from a road traffic accident. Barquet [13] and Schlonsky and Miller [14] also found that the magnitude of forces involved in the injury increased with the age of the patient. In this study, all patients were younger than 10 years of age (15 patients in group I and seven patients in group II).

**Treatment**

**Interval between injury and reduction**

As emphasized by Mehlman et al. [15], the interval between dislocation and reduction must be as short as possible to limit the risk of necrosis. The risk of necrosis is reported to be 3–15% [13, 15, 16]. Although opinions on the treatment differ, it is agreed that prompt reduction of the dislocated hip is the most important initial management [17]. Complete recovery can be achieved only after early reduction; critical delay has been reported by some authors of up to 12 h [17]. More recent articles recommend reduction within 6 h [10, 18] but none of these studies included sufficient number of patients who had undergone hip reduction between 7 and 12 h. Yang et al. [19] found no statistical difference between a delay
established. Several closed reduction maneuvers have been reported previously [22,26]. Manipulation and closed reduction with the patient under general anesthesia may be successful if the delay in treatment is of a short duration (i.e. <3 weeks).

We have performed closed manipulation for six patients who had an interval of less than 24 h between injury and treatment. The result was considered to be normal in all six patients (100%). In other 10 patients with an interval of more than 24 h to less than 3 weeks between injury and treatment, the result was considered to be normal in nine patients (90%) and abnormal in one patient (10%). If the closed reduction failed once or twice, we agree with Nirmal et al. [27] and Sudhir and Anil’s opinion [20] that it should not be attempted any further as fracture of the femoral shaft may occur during manipulation.

Table 1  Time between injury and reduction, method of reduction, range of movement, complications, and Harris score of the hip

<table>
<thead>
<tr>
<th>Number of patients</th>
<th>Time between injury and reduction</th>
<th>Method of reduction</th>
<th>ROM of abduction/adduction</th>
<th>ROM of flexion/extension</th>
<th>ROM of rotation internal/external</th>
<th>Complication</th>
<th>Harris score</th>
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</thead>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Prereduction (°)</td>
<td>Postreduction (°)</td>
<td>Prereduction (°)</td>
<td>Postreduction (°)</td>
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<td>1</td>
<td>3 h</td>
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<td>45</td>
<td>40</td>
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<td>20 45</td>
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<tr>
<td>2</td>
<td>4 weeks</td>
<td>V2</td>
<td>12</td>
<td>40</td>
<td>20</td>
<td>80</td>
<td>5 15</td>
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<tr>
<td>3</td>
<td>14 days</td>
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<td>10</td>
<td>30</td>
<td>20</td>
<td>80</td>
<td>20 35</td>
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<tr>
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<td>5 h</td>
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<td>35</td>
<td>35</td>
<td>100</td>
<td>25 30</td>
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<td>5</td>
<td>5 days</td>
<td>V1</td>
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<td>25 50</td>
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<td>6</td>
<td>9 weeks</td>
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<td>7</td>
<td>13 weeks</td>
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<td>20 35</td>
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<td>8</td>
<td>17 days</td>
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<td>10</td>
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<td>130</td>
<td>20 45</td>
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<td>35</td>
<td>30</td>
<td>95</td>
<td>15 25</td>
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<tr>
<td>19</td>
<td>19 months</td>
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<td>30</td>
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<td>40</td>
<td>125</td>
<td>20 45</td>
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<tr>
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<td>9.2</td>
<td>39.5</td>
<td>35</td>
<td>109.3</td>
<td>18.4</td>
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Table 2  Results of the reduction procedure in all children

<table>
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<th>Method of reduction</th>
<th>Excellent</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
<th>Total</th>
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<tr>
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<td>8 (50.0%)</td>
<td>6</td>
<td>2</td>
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<td>16</td>
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<tr>
<td>Variant 2</td>
<td>2 (40.0%)</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Variant 3</td>
<td>1 (100.0%)</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>8 (36.4%)</td>
<td>7</td>
<td>4</td>
<td>3</td>
<td>22</td>
</tr>
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</table>

Overall, there were excellent results in eight (36.4%) patients, good results in seven (31.8%), fair results in four (18.2%), and poor results in three (13.6%). The average duration of follow-up was 6 years, 8 months (range 2 years, 4 months to 12 years, 9 months).
Treatment should always commence with a careful assessment of history and accurate documentation of the mechanism of injury. In one animal study carried out by Nishino et al. [28], a surgically induced posterior dislocation of the hip was not associated with an avascular change in the femoral head unless the medial and lateral circumflex arteries and veins were also ligated and divided, in which 80% of femoral heads showed evidence of AVN. Ligation of the vessels alone did not cause AVN. The same authors reported that blood flow to the femoral head was reduced to 40.7% of normal by hip dislocation alone, but the addition of a second insult, in the form of circumflex vessel ligation, reduced the blood flow to 14.7% of the normal in the contralateral (normal) hip [28]. The pattern of femoral head necrosis seen on MRI scans was similar to that seen clinically. The authors surmise that a reduction in blood flow below 20% of normal is required to initiate the process of AVN [28].

In a study of cadavers carried out by Yue et al. [29], the femoral vessel filling defects were exaggerated by external rotation of the limb and were improved by internal rotation. Stretching and rotation similarly caused the filling defects in the circumflex vessels. The extraosseous vascular defects did not seem to correlate with changes to intraosseous blood flow. Therefore, after reduction, our patients were immobilized in plaster hip spica immediately, with the hip held in place with hip neutral extension (0°), abduction of about 40–45°, and internal rotation of about 20–30° to improve blood perfusion to the femoral head.

However, closed reduction in infants should be performed carefully because of the risk of slipping of the femoral head dislocation during manipulation [30].

**Open reduction**

Epstein [17] has reported unsatisfactory results after open reduction or open reduction combined with internal fixation of fractures of the acetabular floor or rim. Ghormley and Sullivan [31] reported that unless there are loose fragments in the acetabulum, closed reduction should be the treatment of choice. However, the literature shows insufficient data on the long-term results of closed versus open treatment. We agree with Vedat et al.’s [32] opinion that intra-articular cartilage or bone fragments are always an indication for surgery and do not agree with those who consider that fragments outside the immediate weight-bearing zone are unimportant.

A radiograph, a bone scan, and MRI were performed immediately at admission, which found the wide joint but no fragment fractures of femoral head or acetabulum or labrum interposition of acetabulum in all cases. However, contracture of the capsule and the surrounding musculature makes dislocations of a long duration difficult to reduce and prone to fracture on manipulation [24]. Therefore, we performed V2 in cases of failures of V1 or dislocation of more than 3 weeks. We released the adductor longus muscle and lengthened the psoas tendon to facilitate manipulation and decompression of the hip, to prevent fracture on manipulation, and to prevent subsequent recurrent dislocation.

We had operated on one patient (number 19) with V3: the acetabulum was cleared of all the scar tissue and torn labral fragments. Parts of the very thick posteroinferior capsule were also removed. The femoral head was gently mobilized. The head was gently reduced into the acetabulum. For such a case, some authors would suggest the femoral shortening procedure to decrease the incidence of complications such as AVN, instability, and leg length discrepancy and to improve motion [9,10,22,32]. In this 7-year-old patient, we did not combine surgical debridement of scar tissue with femoral shortening osteotomy. We agree with Kumar et al.’s [8] opinion that the femoral shortening might prolong the operating time, increase blood loss, or increase the incidence of heterotopic bone formation.

**Traction**

Closed reduction with the extremity in heavy traction in abduction has been reported [2,33] to be successful in selected cases. A review of the literature [4,7,8] showed that this method was used in 40 cases of neglected dislocation of the hip in children. The hips could be reduced successfully only in 10 cases. Rieger et al. [11] have not been successful in their attempt to reduce these hips by traction. Therefore, we did not use traction for closed reduction to fix a dislocation of the hip in children in this study.

**Period of non-weight-bearing**

There is no consensus on the length of time required for immobilization after reduction, but the majority of authors suggest 6 weeks in traction or in a hip spica, followed by immediate weight bearing [34].

There is controversy in the literature regarding how much immobilization following reduction is optimal. Banks [33] advised non-weight-bearing for 4–6 months to produce a disuse atrophy; the dense femoral head with AVN would then be obvious. Freeman [1] concluded that patients should remain non-weight-bearing for 2–3 months after injury to prevent synovial irritation. We agree with the Pennsylvania Orthopaedic Society’s report [3], which recommends commencement of weight bearing at 3–6 weeks, to allow for soft-tissue healing.

**Outcome of treatment**

The criteria for the evaluation of postreduction are still controversial, which makes a comparison among different studies difficult (Table 3).

In his classic paper, Harris [5] reported that marked deformity, permanent disability, and great suffering from an old unreduced dislocation of the hip may lead surgeons
to resort to extreme measures to achieve a reduction. Buchanan [24] concluded that although open reduction in an old subluxation is usually difficult, and not altogether free from risks, it is the best treatment. In a review of the literature, Choyce [26] reported open reduction in 15 neglected dislocations of the hip in children, with good results in nine children, satisfactory results in two children, and fibrous ankylosis in one child. The results were not reported for three children. Varma [36] performed open reduction in 14 patients with neglected injuries 14 days–1 year after trauma at the time of reduction. In this study, among six of 22 patients in whom the interval between injury and reduction was more 3 weeks, we found good results in two children, a fair result in one, and poor results in three (Tables 1 and 2).

**Avascular necrosis**

Traumatic dislocation of the hip should be reduced immediately, because every hour of delay increases the risk of a poor result. The delayed reduction increases the risk of osteonecrosis and posttraumatic arthritis [9,15].

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**Table 3** Our result of postreduction of a traumatic dislocation of the hip in comparison with other authors

<table>
<thead>
<tr>
<th>References</th>
<th>Number of patient</th>
<th>Age (years)</th>
<th>&lt;18 years</th>
<th>Dur</th>
<th>Dir</th>
<th>Treatment</th>
<th>AVN</th>
<th>Results</th>
<th>F/U</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunnell and Webster [4]</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>Posterior Traction</td>
<td>CR (7) OR (13) Arthrodesis (3) Cup arthroplasty (6) Total hip (2) Hemiarthroplasty (1)</td>
<td>0/2</td>
<td>Good</td>
<td>40 months</td>
</tr>
<tr>
<td>Garrett et al. [10]</td>
<td>39</td>
<td>13–72</td>
<td>NR</td>
<td>5 days to 9 years</td>
<td>NR</td>
<td>CR (7) OR (13) Arthrodesis (3) Cup arthroplasty (6) Total hip (2) Hemiarthroplasty (1)</td>
<td>NR</td>
<td>CR (0/7 good) OR (3/13 good) Arthrodesis (3/3 good) Cup arthroplasty (4/6 good) Total hip (1/1 good) Hemiarthroplasty (1/1 good) No Rx (6/6 poor)</td>
<td>7 years</td>
</tr>
<tr>
<td>Huckstep [35]</td>
<td>37</td>
<td>NR</td>
<td>NR</td>
<td>&gt;1 month</td>
<td>NR</td>
<td>CR (11) Osteotomy (11) Excision (12)</td>
<td>NR</td>
<td>Variable</td>
<td>Up to 8 years</td>
</tr>
<tr>
<td>Pai [22]</td>
<td>29</td>
<td>29</td>
<td>10/29</td>
<td>3 days to 7 years</td>
<td>Posterior (26) Anterior (3)</td>
<td>CR (3) Heavy traction (9) Excision (8) No Rx (7) Osteotomy (8)</td>
<td>NR</td>
<td>18/22 Satisfactory</td>
<td>2–5 years</td>
</tr>
<tr>
<td>Kumar and Jain [8]</td>
<td>18</td>
<td>4–10</td>
<td>18/18</td>
<td>6–52 weeks</td>
<td>Posterior</td>
<td>Traction (4) OR (21) (21 Anterior, 3 posterior) Excision (2) Osteotomy (1)</td>
<td>18/18</td>
<td>17 Excellent Good/good in 67%</td>
<td>5.1 years</td>
</tr>
<tr>
<td>Varma [36]</td>
<td>28</td>
<td>&lt;12</td>
<td>18/28</td>
<td>2 weeks to 6 years</td>
<td>Posterior</td>
<td>Traction (4) OR (21) (21 Anterior, 3 posterior) Excision (2) Osteotomy (1)</td>
<td>NR</td>
<td>Excellent results (8), good (7), fair (4), poor (3)</td>
<td>6–12 years</td>
</tr>
<tr>
<td>Hung (this study)</td>
<td>22</td>
<td>3–10</td>
<td>22/22</td>
<td>1 day to 19 months</td>
<td>Posterior</td>
<td>CR (16) LP and RA (5) OR (1)</td>
<td>3/22</td>
<td>Excellent results (8), good (7), fair (4), poor (3)</td>
<td>6–12 years</td>
</tr>
</tbody>
</table>

AVN, avascular necrosis; CR, closed reduction; Dur, indicates the duration of dislocation; F/U, follow-up; LP, lengthen psoas; NR, not reported; OR, open reduction; RA, release adductor longus; Rx, treatment.

**Fig. 2**

Patient number 5: A girl, 3 years of age. The patient underwent reduction according to variant 1. (a) The time between injury and reduction was 5 days and reduction was performed according to the Allis method. Before reduction. (b) After reduction, the hip was held in a plaster hip spica for 5 weeks and 2 days, and non-weight-bearing was allowed for 5 months and 3 weeks (normal radiographic image). (c) Final follow-up (normal radiographic image). The patient had normal hip function and radiographic images. Her Harris score was 100 points, an excellent outcome.
In a long-term follow-up of 42 children, Mehlman et al. [15] reported that osteonecrosis was associated significantly with the length of time that a hip remained dislocated. The energy of the injury, the age of the patient, or the absence or presence of an ipsilateral fracture of the hip were all factors associated with the development of osteonecrosis. Mehlman et al. [15] showed that if reduction was delayed more than 6 h, there was a 20 times higher risk of development of osteonecrosis.

Barquet [9] studied 145 hips with AVN after traumatic dislocation in children. Patients younger than 12 years of age had changes similar to Legg–Calve–Perthes disease (i.e. epiphyseal involvement with associated changes), whereas those older than 12 years of age had changes similar to adult AVN (collapse and joint space narrowing) (Figs 2 and 3) (cf. Figs 4–6).

It has been reported that the incidence of AVN in children is comparable to that in adults [9]; however, the incidence has been reported to be less than 5% in recent studies and may develop till 3 years after injury [2,6,12]. Young children (< 6 years of age) whose hips often dislocate in response to a relatively minor trauma seem to be somewhat protected from avascular change despite the theoretical concerns that the hips in these children, if subjected to circulatory changes, might also develop changes that affect the growth plate and the ossific nucleus [11].

**Other complications**

**Neurologic injury**

AVN might be the most feared complication of hip dislocation, but in recent studies, neurologic injury seems to be the most common complication. Sciatic nerve injury...
is the most common type of neurologic injury, and may occur in 5–20% of cases [2,12].

Although all of our patients had posterior dislocation, we did not encounter this complication in our study.

**Recurrent dislocation**

Recurrent dislocation seems to be more common in children than in adults, and may be associated with a defect (tear) in the capsule or attenuation of the hip capsule without a tear. As classified by Ahmadi and Harkess [37], it is a painful, nonvoluntary process that usually requires a formal procedure for relocation of the joint; we did not encounter this complication in our study.

**Heterotopic ossification**

In adults, the incidence of heterotopic ossification is reported to be 2.8% [38]. There are no data on childhood dislocations, although occasional examples have been reported, usually in relation to a fracture of the acetabulum. We did not encounter this complication in our study.

**Coxa magna**

The development of coxa magna did not seem to be related to age, the severity of trauma, the time before reduction, or the method of treatment, and did not affect the clinical outcome. However, Glass and Powell [39] found coxa magna in only 13% of their patients. The etiology of coxa magna is probably a reactive hyperemia secondary to an extensive soft-tissue injury. In this study, we found coxa magna in two patients (Fig. 7).

**Conclusion**

Pediatric patients with a traumatic hip injury should be subjected to reduction of their hips as soon as possible. All patients with a traumatic dislocation of the hip and even patients who have injuries in an accident should be subjected to a careful full-body examination to identify other injuries.

The factors that seem to most influence the final result are as follows:

1. At a time interval between injury and the reduction procedure of less than 3 weeks, manipulation should be performed; 16 of 22 (72.7%) patients underwent...
reduction by manipulation, and a final follow-up without AVN of the femoral head, without poor results, and other complications. Among our patients, three patients (13.6%) had AVN, two (9.1%) had had coxa magna, two (9.1%) patients had a deficient limb, and three (13.6%) patients showed poor results at the final follow-up.

(2) At a time interval between injury and reduction procedure beyond 3 weeks, a reductional operation should be performed; we suggest that the surgeon release the adductor longus, lengthen the psoas tendon, and insert a K-wire. This procedure involves easy manipulation and decompression of the hip and may restrict AVN, and should prevent subsequent redislocation. This simple and safe surgical procedure leads to marked improvement of hip function and prevents the occurrence of complications later. None of the patients in this study had redislocation of the hip.

(3) Plaster hip spica: V1: 6 weeks; V2: 9 weeks, and V3: 12 weeks; the patients are immobilized in a plaster hip spica immediately, the hip is held in place with hip neutral extension (0°), abduction of about 40–45°, and internal rotation of about 20–30°.

(4) After removal of the plaster, each patient underwent a period of crutch-protected non-weight-bearing; for the patient who had undergone reduction according to V1, this time period was 6 months; for V2, it was 9 months, and for V3, it was 12 months.

Acknowledgements
Conflicts of interest

None declared.

References
