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Popliteal angle as an indicator for successful closed reduction of developmental dysplasia of the hip

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ABSTRACT

Purpose. To evaluate the use of the popliteal angle as an indicator for successful closed reduction of developmental dysplasia of the hip (DDH) in children with delayed presentation.
Methods. 29 patients aged 6 to 18 months underwent successful closed reduction for unilateral DDH under general anaesthesia. Using a graduated goniometer, the popliteal angle was measured with the hip abducted within the safe zone (to avoid redislocation and injury to the femoral capital epiphysis) before and after reduction and after 6 weeks of spica casting.
Results. The mean popliteal angles before and after reduction and after 6 weeks of spica casting were 5.1°, 37.5°, and 17.9°, respectively ($p<0.0001$, paired *t* test). Because of discomfort, the spica casts were altered in 3 patients (2 at week 1 and one at week 3).
Conclusion. Reduction of the hip in DDH results in an increased popliteal angle of >20°. This may be used to indicate the diagnosis and safe closed reduction.

Key words: *hip dislocation, congenital; knee joint*

INTRODUCTION

Developmental dysplasia of the hip (DDH) is a common childhood disorder affecting up to 20 in every 1000 live births[1]; 5 such patients may need orthopaedic treatment.[2] Despite advances in clinical and ultrasonographic screening, a number of children still present late (after the age of 4 months).[3–5] Diagnosing late-presenting patients with DDH is difficult, as clinical signs such as the Ortolani and Barlow tests become less reliable when the children grow. Thus, hip abduction can be used as an indicator for DDH, as it is reduced in the dislocated hips.[1,6]

Although there is controversy about the optimal methods of screening and treatment, it is widely accepted that early detection enables less-invasive treatments.[7] The treatment goal is concentric reduction of the femoral head into the acetabulum by closed or open means. This may be augmented by femoral or acetabular osteotomy to maintain coverage of

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the femoral head. Although closed reduction under image guidance is a straightforward procedure, the rate of avascular necrosis (AVN) of the femoral head has been as high as 73%,[8,9] as increased transphyseal and intracapsular pressure may compromise blood flow to the developing proximal femoral physis and epiphysis.[10] Moreover, abduction of the hip increases adductor tension, as the tendons traverse the hip joint, but this tension also contributes to the maintenance of reduction in patients with DDH. Thus, to avoid AVN of the femoral head, it is important to achieve tension-free closed reduction in spica within the safe zone.[9]

Hamstring muscles traverse the hip and knee joints, and thus hip and knee position affects hamstring tension, and vice versa. Thus, the knee position/popliteal angle (the angle subtended between the anterior tibia and the long axis of the femur in the saggital plane) can be used to measure hamstring tension and as an indicator for hip position.

Maintaining reduction of the hip during casting is difficult. When reduction is lost, the spica needs to be removed, the procedure repeated, and inevitably the risk from prolonged general anaesthesia and resorting to repeated manipulation increases. The increase in the popliteal angle secondary to hamstring tightness may be used as an indicator of successful reduction. We evaluated the use of the popliteal angle as an indicator of successful closed reduction in children with delayed presentation of DDH by measuring the popliteal angle before and after closed reduction and after 6 weeks of spica casting.

MATERIALS AND METHODS

Between January 2004 and July 2009, 29 patients aged 6 to 18 months underwent successful closed reduction for unilateral DDH under general anaesthesia. Success was defined as an arthrogram showing proven reduction of the femoral head into the acetabulum without recourse to pre-manipulation traction, adductor tenotomy or open reduction. Patients who underwent an open procedure or pre-reduction traction were excluded.

The popliteal angle was measured 3 times with a graduated goniometer before and after reduction (Fig.). The popliteal angle was measured with the hip abducted within the safe zone to prevent redislocation and injury to the femoral capital physis, although it is usually measured in neutral abduction.[11]

The hips were immobilised in a spica cast within the safe zone. The knees were fully extended while keeping the hip in the joint. Hamstring tension was then released by increasing the popliteal angle slightly in the spica. The position of the hip was confirmed in cast using fluoroscopy.

Six weeks after spica casting, patients were examined under anaesthesia with image intensification. Skin toilet was performed and a new spica applied. The popliteal angle was measured again.

RESULTS

The mean popliteal angles before and after reduction and 6 weeks after spica casting were 5.1°, 37.5°, and 17.9°, respectively ($p<0.0001$, paired t test, Table). Because of discomfort, in 3 patients the spica casts were altered (2 at week 1 and one at week 3).

DISCUSSION

The hamstrings include 4 muscles. The adductor magnus originates from the ischial tuberosity and inserts into the medial femoral condyle. The semimembranosis and semitendonosis originate from the ischial tuberosity and insert into the medial aspect of the tibia and the oblique popliteal ligament, respectively. The biceps femoris long and short

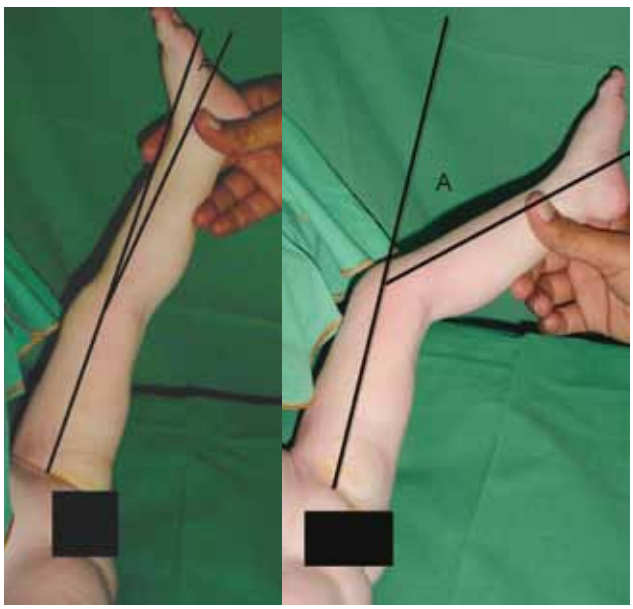

Figure A child with developmental dysplasia of the hip is able to fully extend the knee before reduction and unable to do so after reduction.

heads originate from the ischial tuberosity and the linea aspera, respectively. Both heads insert onto the fibular head.[12] The primary action of the hamstrings is to extend the hip and flex the knee. They also have limited effects in internal and external rotation of the femur. The first 3 muscles are biarthrodial, and muscle tension within them is related to the position of both the hip and knee.

In dislocated hips, the hamstrings are shortened relative to the true anatomy. Restoration of the anatomic position of the femoral head in the acetabulum increases tension in the muscles across the hip. This is then manifested by an increase in the popliteal angle at the knee, consistent with the findings of our study. Prolonged stretching of the hamstrings across the joint in the spica leads to accommodation of the fibres and increases the resting muscle length. This accounted for the reduction in the popliteal angle 6 weeks after spica casting.

In patients with DDH, the popliteal angle is diminished and its use as a clinical indicator may be limited. Nonetheless, in combination with the Galeazzi sign, leg-length inequality, and reduced abduction, it may be useful to determine which hips are reducible and can assist surgical planning.

Application of the spica in the position of the minimum popliteal angle may help maintain the hip in joint, but surgeons should be aware not to maintain excessive tension on the hamstrings. The compression effect on the femoral head physis is detrimental to blood supply.[13] Hamstring tension across the joint can contribute to increased physeal compression and, possibly, AVN of the humeral head. Maintaining the legs in an over extended position also limits the sitting ability of the child. This may limit the usefulness of this clinical sign as a means of

Table
Popliteal angle before and after reduction and after 6 weeks of casting

Patient no.	Popliteal angle (degrees)				
	Before reduction	After reduction	Difference (after – before reduction)	After 6 weeks of spica casting	Difference (after reduction – after 6 weeks of spica casting)
1	3	49	46	22	27
2	6	36	30	17	19
3	9	41	32	15	26
4	5	40	35	14	26
5	5	38	33	19	19
6	3	46	43	20	26
7	5	43	38	20	23
8	8	44	36	25	19
9	7	33	26	12	21
10	10	27	17	17	10
11	9	28	19	20	8
12	7	40	33	20	20
13	7	37	30	14	23
14	3	34	31	15	19
15	8	44	36	18	26
16	6	30	24	13	17
17	6	33	27	19	14
18	0	47	47	20	27
19	3	37	34	23	14
20	2	38	36	18	20
21	2	34	32	19	15
22	5	28	23	17	11
23	8	40	32	16	24
24	4	44	40	16	28
25	3	37	34	23	14
26	5	36	31	19	17
27	2	42	40	14	28
28	0	29	29	17	12
29	7	33	26	17	16
Mean±standard deviation	**5.1±2.7**	**37.5±6**	**32.4***	**17.9±3.2**	**19.6***

* $p<0.0001$, paired t test

maintaining reduction during spica casting.

Increase in the popliteal angle on reduction of the hip in DDH may be an indication for assessing initial reduction and maintenance of the reduction during spica casting. Care should be taken to avoid peak hamstring tension during spica casting.

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