Original Article

Utility of combined hip abduction angle for hip surveillance in children with cerebral palsy

Akshay Divecha, Atul Bhaskar[1]

Abstract

Background: Spontaneous hip lateralization complicates the management of non-ambulatory children with cerebral palsy (CP). It can be diagnosed early using radiographs, but it involves standardization of positioning and exposure to radiation. Hence, the aim of this study was to assess the utility of Combined hip abduction angle (CHAA) in the clinical setting to identify those children with CP who were at greater risk to develop spontaneous progressive hip lateralization.

Materials and Methods: One hundred and three children (206 hips) with CP formed our study population. There were 48 boys and 55 girls aged 2–11 years (mean 5.03 years). 61 children were Gross Motor Function Classification System (GMFCS) level 5, while 42 were GMFCS level 4. Clinical measurements of CHAA were statistically correlated with radiographic measurements of Reimer's migration percentage (MP) for bivariate associations using χ^2 and *t* tests.

Results: CHAA is evaluated against MP which is considered as a reliable measure of hip subluxation. Thus, for CHAA, sensitivity was 74.07% and specificity was 67.35%. False-positive rate was 32.65% and false-negative rate was 25.93%.

Conclusions: Our study shows that correlation exists between CHAA and MP, which has been proved to be useful for hip screening in CP children at risk of hip dislocation. CHAA is an easy, rapid, cost-effective clinical test which can be performed by paraclinical health practitioners (physiotherapists) and orthopedic surgeons.

Key words: Cerebral palsy, combined hip abduction angle, hip subluxation, reimer's migration percentage

Introduction

Spontaneous hip lateralization (subluxation and dislocation) is a serious orthopedic problem seen in children with cerebral palsy (CP), who are non-ambulatory. Its incidence varies from 15 to 35% in recent population studies reported in the literature.[1,2] Hip lateralization is the second most common musculoskeletal deformity after equinus, affecting over one-third of children with CP.[1] It occurs gradually and then progresses to cause development of severe contractures, windswept deformity and scoliosis, resulting in problems with positioning while sitting, and ambulation.[3-5] The hip deformity can also cause secondary problems such as pain, pressure ulcers, difficult nursing care and perineal care, and loss of independence affecting overall quality of life. Extensive surgical procedures are required once the dislocation occurs and the results are not always satisfactory.[6-12] Walking is rarely the aim of surgery in such patients, the indications being relief of pain or for adequate posturing.

Gross Motor Function Classification System (GMFCS) is a valid and reliable tool for the classification of gross motor function and has been described for various age bands.[13,14] Non-ambulators (children in GMFCS 4 and 5) are conclusively identified risk factors for developing hip lateralization.[15,16] Hip surveillance is important in these patients to identify critical indicators, both clinical and radiographic, so that early intervention can be carried out to restore hip location.

Reimer's migration percentage (MP)[17] is a radiographic measure used to quantify hip lateralization on a standardized AP radiograph of pelvis. This requires standardization of positioning of patient to get a reliable radiograph and it involves exposure to radiation. Clinical parameters like range of motion of the hip joint can be measured more easily in the clinic setting. We propose a new clinical measure of range of hip motion called "Combined Hip

Orthopaedic Department, K.J.Somaiya Medical College,
Hospital & Research Centre, [1]Honorary Paediatric Orthopaedic Surgeon,
Bombay Hospital Institute of Medical Sciences, and Paediatric Orthopaedic Surgeon,
Children Orthopaedic Clinic, Oshiwara, Mumbai, India

Address for correspondence: Dr. Akshay Divecha,
J/21,22 Vrushali Shilp C.H.S., New Link Road, Chikoowadi, Borivli (W),
Mumbai – 400 092, India. E-mail: boneexpert@gmail.com

Access this article online	
Quick Response Code:	Website: www.ijoonline.com
	DOI: 10.4103/0019-5413.87129

Abduction Angle" (CHAA). This measurement can be taken serially to detect any loss of hip abduction which should alert the examiner to investigate for hip subluxation.

The aim of this study was to assess the utility of CHAA in the clinical setting to identify those children with CP who were at greater risk to develop spontaneous progressive hip lateralization.

Materials and Methods

This is an observational study on children with CP from 2006 to 2008. The orthopedic consultants and therapists at our clinic were involved in the study. Our inclusion criteria were quadriplegic children who were non-ambulators (GMFCS 5) or functional ambulators (GMFCS 4). Children who have had previous treatment in the form of soft tissue release or botox injections before presenting to us were excluded from our study. Children suspected of having hip pathology other than arising from CP, like trauma, infection, transient synovitis and others, were excluded. Many children involved in the present study were receiving antiepileptics and centrally acting muscle relaxants like Baclofen, which had been started by the treating pediatric neurologist. Over half of them were attending physiotherapy and bracing for their contractures.

Two hundred and fifty-five children attended our clinic during that period; 92 had undergone soft tissue release surgery, 44 children had botox injections, 13 had history of fever and hip tenderness, and 3 children had history of trauma and femur fracture on X-ray. After excluding them, 103 children (206 hips) formed our study population. There were 48 boys and 55 girls aged 2–11 years (mean 5.03 years). Sixty-one children were GMFCS level 5, while 42 were GMFCS level 4.

CHAA was measured by the treating orthopedic surgeon (AD and AB) and the therapists in the clinic.

Technique of measurement

With the child in supine position after passive stretching for 5 minutes, CHAA was measured using goniometer, as the angle made between the axes of both thighs with both hips and both knees in flexion. Two persons would be required to make the measurement; one holds the thigh while the other uses the goniometer to make the measurement [Figure 1]. This was done to relax hamstrings and psoas muscles of both sides so that the hip abduction could be done as much as possible. This also coincides better with the position of hip and knee during sitting posture of the child. Our measurements were in increments of 5° for ease of calculation and interpretation.

Plain radiograph of the squared pelvis was taken for all children using the standardization method to correct lumbar lordosis, pelvic obliquity[18] and torsion of proximal femoral geometry due to hip and knee flexion contracture. Reimer's index, also known as migration percentage (MP),[17] was calculated using standardized pelvis AP radiograph [Figure 2]. MP calculation also involved a least count of 5% for ease of measurement. In many cases, radiographs were needed to be repeated with better positioning.

We believed that CHAA of ≤40° should alert the examiner for further evaluation of child's hip. So, the study population was divided into two groups of CHAA of ≤40° which was considered bad (Group X) and >40° which was presumed good (Group Y)

MP of ≥33% is recommended as a threshold for reaction or intensified observation.[19] So, hips with MP ≥33% were considered bad and those with MP <33% were presumed to be good. So, our study population could be divided into three categories of BB (both MPs were bad), GG (both MPs were good), and BG (one side bad and the other side good).

We statistically analyzed the correlation between clinical

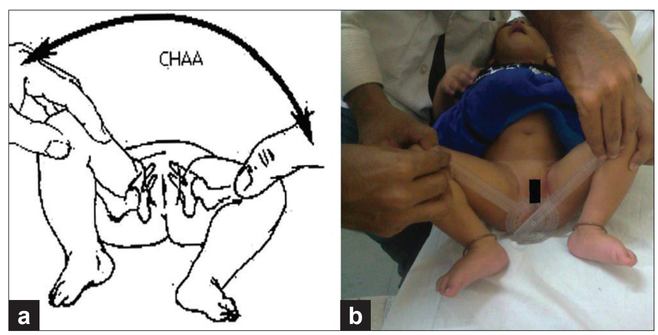

Figure 1: (a) Line diagram demonstrating the technique of measuring CHAA. (b) Use of goniometer and two persons to measure CHAA

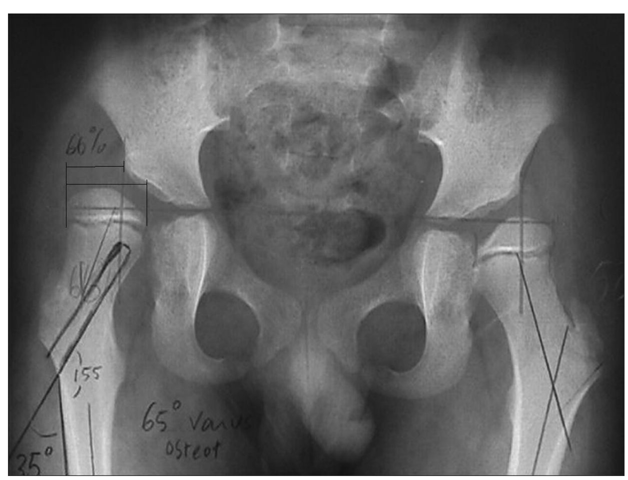

Figure 2: Measurement of Reimer's migration percentage (MP)

measures of CHAA with radiographic measurements of MPs of the hips in a CP child. We included all children with bilateral bad MPs (BB) and those who had unilateral bad MP (BG) to form a common group against the group of children with good MPs (GG) in both hips.

For the analysis, descriptive statistics were first calculated followed by bivariate associations using χ^2 and *t* tests. All analyses were conducted using SPSS 15 software with a minimum level of statistical significance set at 0.05.

Results

Using statistical analysis, we concluded that there was no statistically significant difference in our groups as far as age, sex, and GMFCS levels were concerned. Comparison between our CHAA groups can be seen in Table 1. Results of CHAA and MP calculated in children included in our study are presented in Tables 2-4.

CHAA is tabulated against MP which is considered as reliable measure of hip subluxation. We included all children with bilateral bad MPs (BB) and those who had unilateral bad MP (BG) to form a common group against the group of children with good MPs (GG) in both hips. Table 5 shows the percentage of children with good and bad CHAA in the two MP groups (BB + BG) and (GG). Thus, for CHAA, sensitivity was 74.07% and specificity was 67.35%. False-positive rate was 32.65% and false-negative rate was 25.93%. Youden's index was 0.41. Likelihood ratio for positive test was 2.27 and for negative test was 0.38. Diagnostic odds ratio was 5.9. CHAA was less than 40° (Group X) in 56 children, and in 47 children the CHAA was more than 40° (group Y).

We found out that out of 24 BB children, 22 (91.7%) had bad CHAA. However, out of 30 BG children, 18 (60%) had bad CHAA while 67.3% of the GG children had good CHAA. According to GMFCS, we found that the mean CHAA was less in level 5 as compared to level 4.

Table 1: CHAA groups comparison

	CHAA ≤ 40 (group X)	CHAA > 40 (group Y)
Age mean, years (range)	5.15 (2–11)	4.89 (2–8.5)
Sex M/F	26/30	22/35
GMFCS level 4/5	20/36	22/35

CHAA: Combined hip abduction angle

Table 2: Means, medians and ranges of our results in 103 patients

	Mean	Median	Range
CHAA	39.42	40	10–70
Right MP	35.34	30	10–100
Left MP	36.07	30	10–100

Table 3: Means and ranges of our findings in study population according to GMFCS

GMFCS	CHAA	Right MP	Left MP
4 (42 children)	42.5 (15–70)	35.71 (10–100)	32.26 (10–70)
5 (61 children)	37.3 (10–65)	35.08 (10–100)	38.69 (10–100)
Total	39.42 (10–70)	35.34 (10–100)	36.07 (10–100)

GMFCS: Gross motor function classification system, CHAA: Combined hip abduction angle, MP: Migration percentage

Table 4: Means and ranges of our findings in study population according to M:F

M:F	CHAA	Right MP	Left MP
55 F	38.45 (10–65)	35.09 (10–100)	38.73 (10–100)
48 M	40.52 (10–70)	35.63 (10–100)	33.02 (10–100)
Total	39.42 (10–70)	35.34 (10–100)	36.07 (10–100)

CHAA: Combined hip abduction angle, MP: Migration percentage

Table 5: Contingency table for CHAA

		MP (right and left)		Total
		Either bad (BB + BG)	Bilateral good (GG)	
CHAA	X	40 (71.4)	16 (29.8)	56 (52.4)
	Y	14 (28.6)	33 (70.2)	47 (47.6)
Total		54 (100)	49 (100)	103 (100)

CHAA: Combined hip abduction angle, BB: Bilateral bad, BG: Bilateral good, Figures in parenthesis are in percentage

Discussion

Many studies have shown the predictive ability of MP for hip surveillance in CP.[1,2] Some studies have concluded that measurement of the range of motion is a poor indicator of risk and cannot replace radiographic examinations for hip screening.[2,22] However, Hägglund *et al*. have mentioned that a decreasing hip range of motion over time in an individual child could warrant radiographic hip examination.[2] But to the best of our knowledge, there has been no study in which the utility of CHAA for Hip surveillance has been systematically analyzed.

The hip of a CP child is normal at birth. The proximal femoral geometry undergoes progressive changes in the form of decrease in femoral neck anteversion and neck shaft angle to form stable hip during the initial years of life, only if stimulated by ambulation.[20-22] Increased femoral neck anteversion is related to dysfunction of gait, whereas increased neck shaft angle is related to progressive functional inability measured by GMFCS, while both these contribute to hip lateralization.[21,23]

Our results indicate that a correlation exists between the CHAA and MP. It was noted that 40 children with CHAA <40° had MP >33% in one or both hips. Many such children ultimately landed up with botox injections, soft-tissue releases and, in severe cases, osteotomies. Some neglected dislocations with severely restricted CHAA were considered unsuitable for surgery and were left alone.

Sixteen children with CHAA <40° had MP <33% on both sides. This may be due to persistent spasm in an irritable child. Therefore, adequate pacification is needed during the test to allow the child to relax. Furthermore, CHAA <40° should always be followed by standardized radiograph to know the status of the hips.

Fourteen children with CHAA >40° had MP >33% on one or both sides. But it may have been due to variation in passive stretching between observers. However, it can be considered insignificant as it is a small percentage.

Hence, we recommend CHAA of 40° to be taken as the threshold for orthopedic referral and imaging of hips to rule out hip lateralization. Many of these children attend physiotherapy sessions and are rarely referred to an orthopedic surgeon in our country until there is gross deformity. This test will help those involved in the care of CP children to identify those at risk for early referral before it is too late.

In our study, CHAA had sensitivity of 74.07% and specificity of 67.35%. However, we should realize that we have kept functional ambulators and non-ambulators as the selection criteria in the present study rather than selecting patients based on MP values and then measuring CHAA in them. The latter method would have given true sensitivity and specificity. This is a limitation of the present study.

False-positive rate is 32.65% and false-negative rate is 25.93%. It thereby behooves us to use it as a primary screening test and should be followed by radiograph in all suspected cases.

Soo *et al*. have suggested that assessing patients using GMFCS is more significant than knowing the motor type, for example, spastic, dystonic, mixed or hypotonic, as the incidence of hip displacement in all of them is similar.[1] So, effort was not made to classify the patients using motor type. Only GMFCS was used to classify the severity of CP in our patients. As hypotonic patients also have equal incidence of hip displacement, CHAA could give false-negative values in such patients.

Although GMFCS is only valid after 6 years, we have used this in our study to classify the children into two broad categories: functional ambulators and non-ambulators.

Our measurements were made in increments of 5 (least count) for convenience of measurement and computing. Also, it may take care of some inter- and intra-observer reliability.

Patients with fixed infrapelvic obliquity may pose a dilemma as the abduction of one hip may mask the adduction contracture of a subluxated hip and give a wrongly increased CHAA. But these patients can be identified clinically due to pelvic obliquity and radiographic evaluation can be carried out in them.

It was further noticed that the MP was more or less symmetric in some of our patients. This is due to the systemic nature of the illness and it further ascertains the concept of CHAA. Also, measurement of isolated hip range of motion is cumbersome and unreliable.

Our study included only 206 hips. So, this can be considered a preliminary pilot study and warrants longitudinal study involving significant number of patients with serial measurements which may further show the significance of CHAA. The significance of rate of decrease of CHAA can be found in such studies which was not possible in our study. One more limitation of our study is that we have not accounted for grading of spasticity and how it affects our results. This can be done using Modified Ashworth Scale but has been proved to be unreliable in CP.[24]

In the future, we hope to be able to discover those group of children in the population who are at risk of dislocation of the hip in relation to subtype of CP, function including CHAA and other information from the collected data. We also hope to improve the interpretation of CHAA, with more emphasis on the rate of decrease in CHAA which precedes hip lateralization.

References

1. Soo B, Howard JJ, Boyd RN, Reid SM, Lanigan A, Wolfe R, *et al*. Hip displacement in cerebral palsy. J Bone Joint Surg Am 2006;88:121-9.
2. Hägglund G, Lauge-Pedersen H, Wagner P. Characteristics of children with hip displacement in cerebral palsy. BMC Musculoskelet Disord 2007;8:101.
3. Bagg MR, Farber J, Miller F. Long-term follow-up of hip subluxation in cerebral palsy patients. J Pediatr Orthop 1993;13:32-6.
4. Samilson RL, Carson JJ, James P, Raney FL. Results and complications of adductor tenotomy and obturatorneurectomy in cerebral palsy. Clin Orthop 1967;54:61-73.
5. Letts M, Shapiro L, Mulder K, Klassen O. The windblown hip syndrome in total body cerebral palsy. J Pediatr Orthop 1984;4:55-62.
6. Eilert R, MacEwan G. Varusderotational osteotomy of the femur in cerebral palsy. Clin Orthop 1977;125:168-72.
7. Miller F, Girardi H, Lipton G, Ponzio R, Klaumann M, Dabney KW. Reconstruction of the dysplastic hip with peri-ilial pelvic and femoral osteotomy followed by immediate mobilization. J Pediatr Orthop 1997;17:592-602.
8. Castle ME, Schneider C. Proximal femoral resection-interposition

arthroplasty. J Bone Joint Surg Am1978;68:1051-4.
9. Root L, Siegal T. Osteotomy of the hip in children: Posterior approach. J Bone Joint Surg Am 1980;62:571-5.
10. Tylkowski CM, Rosenthal RK, Simon SR. Proximal femoral osteotomy in cerebral palsy. Clin Orthop Relat Res 1980;151:183-92.
11. Bleck EE. Orthopaedic management in cerebral palsy. London: MacKeith Press; 1987. p. 99-371, 440-70.
12. Koffman M. Proximal femoral resection or total hip replacement in severely disabled cerebral-spastic patients. Orthop Clin North Am 1981;12:91-100.
13. Palisano R, Rosenbaum P, Walter S, Russell D, Wood E, Galuppi B. Development and reliability of a system to classify gross motor function in children with cerebral palsy. Dev Med Child Neurol 1997;39:214-23.
14. Wood E, Rosenbaum P. The gross motor function classification system for cerebralpalsy: A study of reliability and stability over time. Dev Med Child Neurol 2000;42:292-6.
15. Howard CB, McKibbin B, Williams LA, Mackie I. Factors affecting the incidence of hip dislocation in cerebral palsy. J Bone Joint Surg Br 1985;67:530-2.
16. Lonstein JE, Beck K. Hip dislocation and subluxation in cerebral palsy. J Pediatr Orthop 1986;6:521-6.
17. Reimers J. The stability of the hip in children: A radiological study of results of muscle surgery in cerebral palsy. Acta Orthop Scand 1980;184:1-100.
18. Scrutton D. The early management of hips in cerebral palsy. Dev Med Child Neurol 1989;31:108-16.
19. Hägglund G, Lauge-Pedersen H, Persson M. Radiographic threshold values for hip screening in cerebral palsy. J Child Orthop 2007;1:43-7.
20. Beals RK. Developmental changes in the femur and acetabulum in spastic paraplegia and diplegia. Dev Med Child Neurol 1969;11:303-13.
21. Robin J, Graham HK, Selber P, Dobson F, Smith K, Baker R. Proximal femoral geometry in cerebral palsy: A population-based cross-sectional study. J Bone Joint Surg Br 2008;90:1372-9.
22. Birkenmaier C, Jorysz G, Jansson V, Heimkes B. Normal development of the hip: A geometrical analysis based on planimetric radiography.J Pediatr Orthop B 2010;19:1-8.
23. Gage JR, Deluca PA, Renshaw TS. Gait analysis: Principles and applications. J Bone Joint Surg Am 1995;77:1607-23.
24. Mutlu A, Livanelioglu A, Gunel MK. Reliability of ashworth and modified ashworth scales in children with spastic cerebral Palsy. BMC Musculoskelet Disord 2008;9:44.

How to cite this article: Divecha A, Bhaskar A. Utility of combined hip abduction angle for hip surveillance in children with cerebral palsy. Indian J Orthop 2011;45:548-52.

Source of Support: Nil, **Conflict of Interest:** None.