Original Article

Early Radiological Results of Femoral Varus Derotation Osteotomy in Spastic Cerebral Palsy

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ABSTRACT

Objectives: The aim of the study was to evaluate the early radiological changes after femoral varus derotation osteotomy (VDRO) in spastic cerebral palsy (CP) patients with hip subluxations and correlating the effects of healing and remodeling of the osteotomy on the containment of the hip on a short term basis.

Venue: Al-Razi Orthopedic Hospital, Kuwait

Subjects and methods: We performed a femoral varus derotation osteotomy on 17 patients (29 hips) with spastic cerebral palsy presenting with hip subluxations or dislocation. The radiological changes occurring after healing of the osteotomies were followed up for a maximum of 16 months. The radiological assessment included Reimers migration percentage (MI%), femoral neck shaft (FNS) angle and acetabular index (AI). These parameters were assessed preoperatively, immediate postoperative films, and 14-16 months postoperatively.

Results: The results were graded as good, fair and poor. A good result is achieved when the hip is contained, the migration percentage is less than 5%, and the femoral neck shaft angle is from 100-115 degrees. A poor result is achieved when the Reimer's index is > 25% and femoral neck shaft angle is > 130 degrees. Analysis of the results, and the reasons for poor results are presented.

Conclusion: Spastic cerebral palsy with hip subluxation may progress to complete dislocation. Femoral VDRO improves the containment of the hip and its stability on a short-term basis. Remodeling at the osteotomy site may cause recurrence of the coxa valga especially in the younger age groups. This recurrence may affect the containment and stability of the hip especially in those patients with high MI% and high AI. To decrease this effect of remodeling of the osteotomy on the containment of the hip, the femoral neck shaft angle at the time of the osteotomy should be kept below 115 degrees. In patients with a high MI% and high AI, VDRO alone does not maintain the hip containment adequately.

KEYWORDS: cerebral palsy, dislocation, femoral varus-derotation osteotomy, hip subluxation

INTRODUCTION

Cerebral palsy is a disorder of movement and posture caused by non-progressive defect or lesion in the immature brain. The clinical presentation of cerebral palsy varies according to the extent and location of the lesion in the brain. Spastic cerebral palsy constitutes the majority of patients referred to the orthopedic surgeon for management of deformities resulting from contractures developing during growth of the affected children. Dislocation of the hip in these patients is common and usually occurs around the age of seven years[1]. The incidence of the dislocation varies in the literature and is estimated to be between 2.5 - 28%[2-4]. In the severely affected children the incidence of hip dislocation may reach up to 75%[3,5].

The combination of delayed weight bearing, spasticity, muscle weakness with the presence of the flexion adduction contractures contributes largely to the development of hip subluxation and dislocation in spastic CP children.

The important muscular forces that lead to dislocation are over activity of the adductors and hamstrings[6,7], over activity of the iliopsoas[1,3,6] and weakness of the gluteus medius and maximus[8]. Increased coxa valga with persistent anteversion[6,7,9] by the previous muscle imbalances lead to shifting of the center of rotation of the hip to the lesser trochanter[10,11]. All these forces lead to lateralization of the femoral head with subsequent subluxation and eventual posterior dislocation. Following the posterior dislocation, acetabular index increases[7]. Several studies have documented a 50% incidence of pain in cerebral palsy patients with hip dislocations[12-14]. In Bagg *et al* series[15], he showed that hips with MI < 50% may reduce spontaneously or at least remain subluxated. Hips with MI > 50% remained subluxated or progressed to dislocation.

To prevent and/or treat this problem a combination of soft tissue releases with or without

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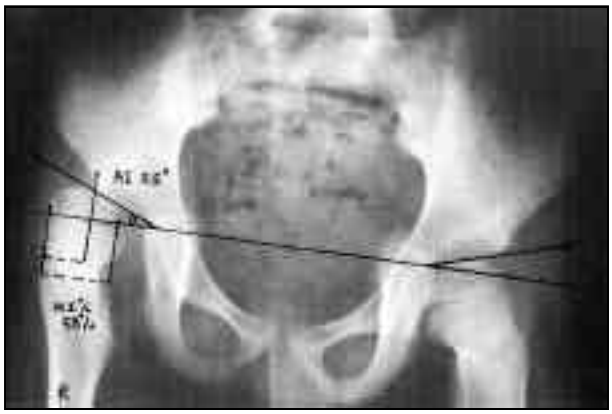

Fig. 1: Case No. 17, Preoperative X-ray showing right hip subluxation

Fig. 2: Case No. 14, Preoperative X-ray showing right hip dislocation

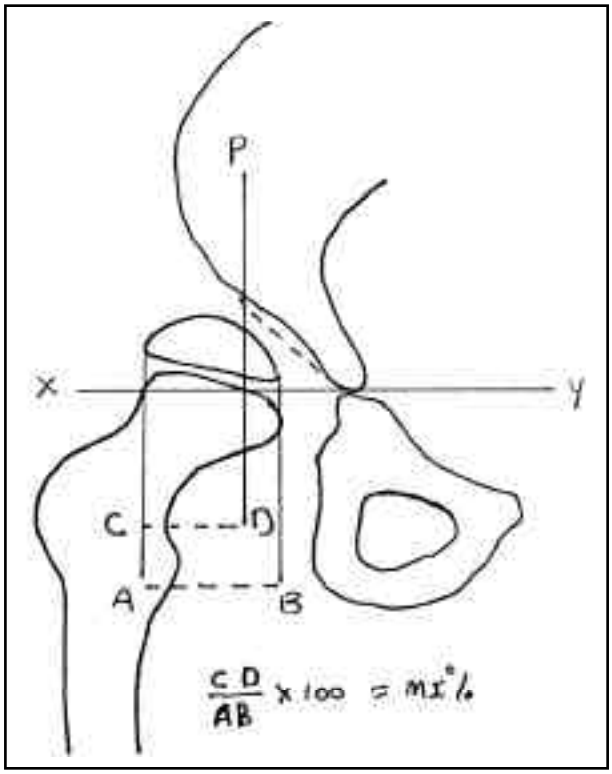

Fig. 3: Diagram showing the Reimer migration index (MI)

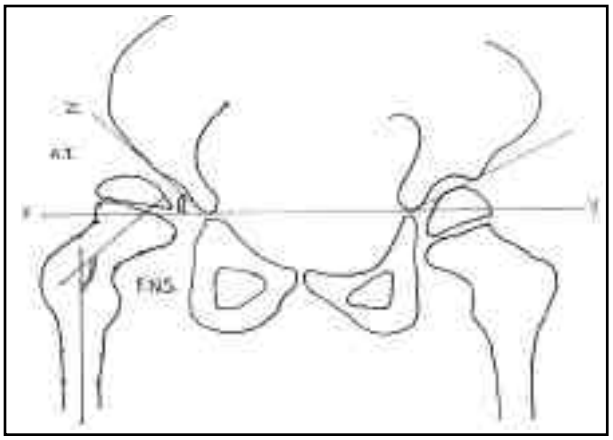

Fig. 4: Diagram showing lines drawn to measure femoral neck shaft angle (FNS) and acetabular index (AI)

osteotomies of the proximal femur and / or acetabulum are usually performed.

In this study we performed proximal femoral varus derotation osteotomy (VDRO) in patients with spastic cerebral palsy with hip subluxation or dislocation and assessed the effect of healing of the osteotomy on the containment of the hip on a short term basis. Though it is well known, that remodeling of the femoral neck following varus derotation osteotomy continues to occur till the physes of the femoral neck closes[16], we wanted to correlate the direct effects of healing of the osteotomy one to one and half years postoperatively eliminating the correction that occurs through remodeling by growth contribution from the upper femoral physes.

MATERIALS AND METHODS

We performed a femoral VDRO on 17 consecutive patients (29 hips) with spastic cerebral palsy. These patients were assessed radiologically preoperatively and postoperatively for a maximum of 16 months.

Out of 17 patients, eight were female and nine were male. The ages at the date of presentation for surgery ranged from two years and six months up to 10 years 8 months. Eleven patients were between three and five years. A total number of 29 hips were operated. Twelve patients had bilateral VDRO and five patients had unilateral VDRO.

Out of 17 patients, ten were diplegics, two were quadriplegics and five had total body involvement with global developmental delay. The usual reasons for presentation to our clinic were adduction flexion deformity of the hips with scissoring gait (10 patients) and delayed walking (all 17 patients). Only one patient presented with pain. All patients had spastic form of cerebral palsy, five patients did not have sitting balance (total body involvement), eight patients were wheelchair dependant and eight out of the ten diplegic patients could walk with some form of assistance. All patients had either hip subluxation or dislocation.

Fig. 5: Case No. 1, Preoperative X-ray showing right hip subluxation

Fig. 6: Case No. 9, Operative X- rays showing measurement of FNS angle at time of soft tissue releases

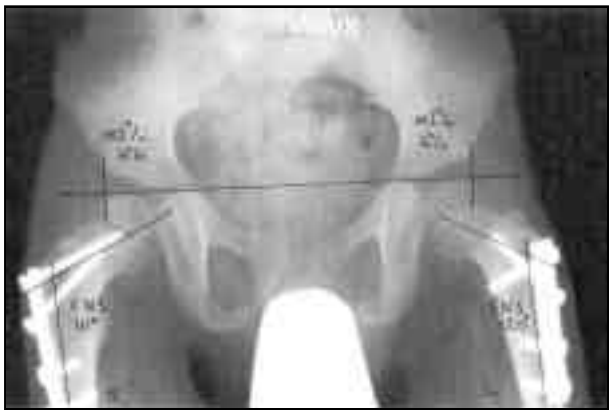

Fig. 7: Case No. 9, Postoperative X-rays after 16 months showing a good result

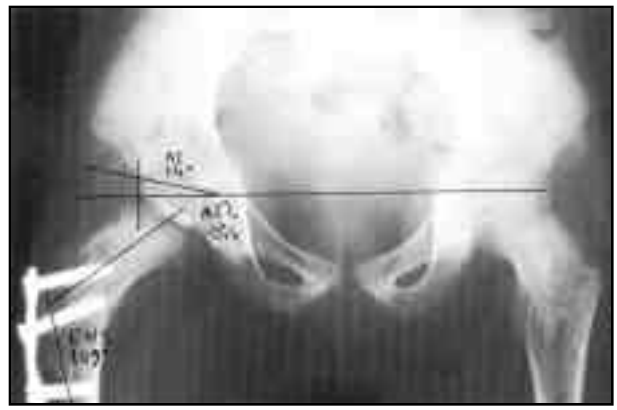

Fig. 8: Case No. 1, Postoperative X-rays after 16 months showing a good result

The main indications for surgery were correction of hip subluxations (14 patients, 25 hips) and dislocations (3 patients, 4 hips, Fig. 1 and 2). In addition, secondary goals were to correct deformity to achieve balance (sitting or standing) in all 17 patients and to facilitate personal hygiene in four patients.

Our routine procedures were to perform open soft tissue releases of adductors and iliopsoas, manual repositioning of the hips (16 patients), apply above knee cast with broomstick with the hips in the position of abduction and internal rotation for three weeks followed by a second stage surgery VDRO. One patient had a closed adductor tenotomy abroad (case No. 7). Two patients had anterior obturator neurectomy because the abduction angle was less than 20 degrees (case No. 6), and early presentation of complete hip dislocation (case No. 15) and one patient had a hip flexor release (case No. 2). None of the patients had open reduction of the hips and none had pelvic osteotomy to augment the acetabular dysplasia.

All the patients had femoral varus derotation osteotomy (VDRO, 29 hips). The usual methods of fixation were plates and screws. Postoperatively the patients had plaster spica for 4 - 6 weeks.

All patients had sound clinical and radiological union and none had infections. One patient had a sacral sore which healed in less than 21 days. One patient had a hypertrophic scar. One case had bilateral supracondylar fractures of the femora following removal of the hip spica (case No. 12).

Radiological assessment of the operated hips was made using migration percentage of Reimers (MI%)[17], the acetabular index (AI) and the femoral neck shaft angles (FNS, Fig. 3 and 4). A MI of < 5% is a contained hip, 25% or less is mild subluxation, 26 - 50% is moderate subluxation, 51-100 is severe subluxation and > 100% is a dislocation.

The preoperative films were used to assess the acetabular index and migration percentage (Fig. 5). According to Reimer's method[17], this is taken in the supine position with the hips in neutral rotation and neutral abduction - adduction (knees beside each other and patellae facing strictly forwards). Because all these patients had excessive anteversion of the femoral neck as assessed clinically by increased range of internal rotation (> 80 - 90 degrees with the hips extended), we measured the femoral neck shaft angles at the time of adductor iliopsoas release and after manual repositioning of the hip with an X-ray taken in full internal rotation. This helped us to properly visualize the APprofile of the

Table 1: Preoperative radiological parameters of 29 hips

Case No.	Preoperative					
	MI%		AI		FNS°	
	R	L	R	L	R	L
1.	70	—-	31	—-	129	—-
2.	42	—-	32	—-	133	—-
3.	25	50	26	30	170	165
4.	26	26	19	25	146	140
5.	50	21	27	23	136	143
6.	57	81	31	35	148	149
7.	35	25	20	16	134	137
8.	100	100	35	35	154	154
9.	76	76	15	15	144	148
10.	21	25	22	25	140	143
11.	31	42	25	27	138	136
12.	73	55	36	32	138	143
13.	54	35	26	21	138	143
14.	100	—-	40	—-	142	—-
15.	—-	100	—-	33	—-	144
16.	64	27	35	29	157	154
17.	58	—-	25	—-	130	—-

Table 2: Postoperative radiological parameters of 29 hips

Case No.	Immediate postoperative				Late postoperative					
	MI%		FNS°		MI%		AI		FNS°	
	R	L	R	L	R	L	R	L	R	L
1.	0	—-	107	—-	0	—-	14	—-	109	—-
2.	0	—-	115	—-	24	—-	31	—-	110	—-
3.	6	24	119	120	25	**35**	26	26	125	127
4.	0	0	113	126	8	12	27	23	122	125
5.	17	0	108	121	17	8	30	22	118	120
6.	19	27	122	126	14	19	20	28	130	125
7.	0	0	112	116	0	4	20	19	115	121
8.	27	19	117	109	**27**	**26**	33	32	120	115
9.	4	4	117	118	4	4	18	18	111	120
10.	0	0	118	127	4	4	18	16	117	120
11.	0	0	108	120	13	17	27	27	110	120
12.	22	28	110	111	4	6	34	31	109	112
13.	19	11	121	121	22	3	28	16	130	125
14.	25	—-	118	—-	**50**	—-	39	—-	130	—-
15.	—-	0	—-	103	—-	0	—	30	—-	105
16.	0	14	115	113	**36**	**27**	35	30	124	138
17.	0	—-	110	—-	0%	—-	26	—-	108	—-

* values plotted in bold in late postoperative parameters are those with poor results (MI% > 25%).

femoral neck by correction of the ante-version in accordance with Samilson's method[1] (Fig. 6). The anteversion was not measured in all cases based on the observations of Kay[18], that it is the external rotation that can change the apparent femoral neck shaft angle measurements to more than 10 degrees.

The immediate postoperative films were used to assess the migration percentage and femoral neck shaft angles. These films were also compared with films taken at 14-16 months. All postoperative measurements were taken with the legs in neutral position with knees beside each other (rotation had been corrected by the surgical maneuver), patellae facing strictly forwards with no external rotation allowed.

Table 3: Number of hips with measured FNS angle at preoperative and postoperative periods

Period	Number of Hips				
	FNS < 100°	FNS 100-120°	FNS 121-130°	FNS 131-145°	FNS > 145°
Preoperative	—	—	2	17	10
Immediate postoperative	—	22	7	—	—
Late postoperative	—	17	11	1	—

RESULTS

The preoperative, immediate postoperative and the late postoperative values of FNS, MI% and AI are shown in Table 1 and 2.

A. Femoral neck shaft angle (FNS):

In preoperative films, all 29 hips had FNS angle of 121° or above (27/29 hips had an angle > 131 degrees). In the immediate postoperative films 22/29 hips were corrected to angles between 100-120 degrees (Table 3). The late postoperative X-rays showed that five out of 22 hips had an increase in the FNS angle to more than 121 degrees during the process of union (22.7%).

While comparing the immediate postoperative films with those 16 months postoperatively, out of the 12 hips with FNS angle of > 121 degrees, we noticed that there is an increase in the FNS angle ranging from 4 - 25 degrees in the late postoperative group with an average of 9.3 degrees due to the process of remodeling of the osteotomy. All these patients were younger than five years of age (Table 4).

B. Migration percentage (MI%):

This was measured at preoperative films, immediate and late postoperative films respectively (Table 5). At preoperative films, all hips had subluxation or dislocation as assessed by the migration percentage. Out of these, 24/29 hips had a migration percentage > 25. At the immediate postoperative films, only 16/29 hips could be brought to containment with a migration percentage < 5. At late postoperative films, only 11/29 hips had a MI % < 5. This denotes a recurrence of subluxation in 5/29 hips.

C. Acetabular index (AI):

This was also measured at preoperative films and compared with late postoperative films (Table 6). At preoperative films, 17/29 hips had a AI value of < 30 degrees. At late postoperative films 19/29 hips had an AI < 30 degrees.

Table 4: The effect of remodeling of osteotomy on the measurement of FNS angle, age related, recurrence of valgisation (> 121 degrees) in 10/29 operated hips. The containment grade in these cases is also shown.

Case No.	Age at surgery	Hip side	Immediate post-operative FNS°	Late post-operative FNS°	Change	Grade
3.	3 y 5 m	R	119	125	+ 6	F
		L	120	127	+ 7	P
4.	4 y	R	114	122	+ 8	F
		L	126	125	≤ 1	F
6.	4 y	R	122	130	+ 8	F
		L	126	125	≤ 1	F
7.	2 y 6 m	L	116	121	+ 5	G
13.	4 y 9 m	R	121	130	+ 9	F
		L	121	125	+ 4	G
14.	4 y	R	118	130	+ 12	P
16.	2 y 8 m	R	115	1 24	+ 9	P
		L	113	138	+ 25	P

* Cases marked as ≤ 1 giving a margin of error in measurement + or - one degree. F = fair, G = good, P= poor, y = year, m = month

Containment of the hip:

The results were graded as good, fair and poor by assessing the hip containment as below. A good result is a MI% of < 5% and FNS angle 100-115. A fair result is MI% of 6-25% and a FNS angle 115-130. A poor result is given to a MI% > 25 and a FNS angle > 130 degrees. A lower grade is given to mixed results *e.g.*, if the MI% is 6 - 25 (fair) and FNS angle is 100-115 (good) the grade is fair. The same grade is given if the MI% is < 5 (good) and FNS shaft angle is 115-130 (fair).

A good result denotes a well contained hip. A fair result denotes mildly dysplastic hip, with a mild hip subluxation. A poor result denotes a moderately dysplastic and moderately subluxated hip (Fig. 7 and 8).

Out of 29 hips, 11 were good, 12 were fair and 6 were graded as a poor result. Statistical analysis using the Wilcoxon two sample test (Table 7) revealed that results for the poor outcome are significant for the FNS (p value = 0.01) and MI (p value = 0.02) and not significant for AI. Comparing the figures in the immediate postoperative and 16 months films, the median for FNS was 116 degrees (IQR 113-118), and 125.5 degrees (IQR 120-130) respectively. The median for the migration index was 21.5% (IQR 14-25%), and 31% (IQR 27-36%) respectively.

DISCUSSION

We tried to assess the direct effects of healing and early remodeling of the femoral VDRO on the femoral neck shaft angle obtained at immediate postoperative period with that after a period less than one and half year and correlate the effects of this healing on the containment of the femoral head inside the acetabulum by measuring two parameters, femoral neck shaft angle (FNS) and the Reimer's migration index (MI%). These measurements were compared with the preoperative measurements. We did not use the acetabular index (AI) as in these cases we did not attempt to do any acetabular procedures or pelvic osteotomies to augment the acetabular dysplasia.

Table 5: Number of hips comparing MI% at preoperative and postoperative periods

Migration percentage	Number of Hips		
	Preoperative	Immediate postoperative	14-16 months
< 5	---	16	11
6-25	5	10	12
26-50	10	3	6
>50	14	---	---

Comparing the immediate and the late postoperative films of the 12 hips with FNS angle > 121 degrees, we noticed that there is an increase in the FNS angle ranging from 4 - 25 degrees with an average of 9.3 degrees due to the process of remodeling of the osteotomy (Table 4). In comparison to Hoffer *et al* series[11] the remodeling of the osteotomy at FNS angle resulted in valgisation of 10-14 degrees. It is to be noted that his cases were followed for an average of seven years compared to this series where the follow up was for less than one and half years.

Returning to the surgical procedure, the question is of how much varus should be attempted at osteotomy? In Samilson's series[1], he advocates an angle of 90-100 degrees. In Hoffer's series[11] he advocates an angle of 100 -120 and angles upto 130 were acceptable. He compared the remodeling in patients < 9 years old to those > 9 years. In the younger age group, the remodeling averaged 14 degrees compared to 10 degrees in the older age group[11]. Root and Siegal[19] suggested an angle of 100-110 for patients < 8 years and 115 -120 for patients > 8 years. In our series, there was a recurrence of valgisation averaging 9.3 degrees. In Mazur's series[16] of 75 hips with proximal femoral osteotomies, he found that remodeling was variable between patients. In children younger than four years, remodeling was more than in children above this age. In our series we did not attempt to pre-determine at preoperative films the exact FNS angle we desired, rather we attempted to bring it to the best contained position and we decide the amount of wedge needed to be resected. All the patients who had early recurrences of valgisation were less than five years old.

We feel it is reasonable to follow the age

Table 6: Number of hips with AI < 30 and > 30 degrees at preoperative and postoperative periods

Period	Number of Hips	
	Acetabular index ≤ 30°	Acetabular index ≥ 30°
Preoperative	17	12
14-16 months	19	10

Table 7: Statistical analysis of radiological parameters related to containment grade using Wilcoxon-2 sample test.

Parameter		Result Grade		
		Good	Fair	Poor
FNS				
	Immediate postoperative	116 (110-118)	119.5 (112-121.5)	*116 (113-118)
	16 M postoperative	115 (109-120)	121 (115-125)	*125.5 (120-130)
MI				
	Immediate postoperative	0% (0-4%)	3% (0-19%)	** 21.5% (14-25%)
	16 M postoperative	4% (0-4%)	15.5% (10-20.5%)	** 31% (27-36%)
AI				
	Preoperative	22 (16-31)	26.5 (25-31.5)	35 (30-35)
	16 M postoperative	18 (16-26)	27 (24.5-29)	32.5 (30-35)

Wilcoxon-two sample test
- * p value= 0.01
- ** p value = 0.02
- all values are median
- ( ) values are IQR (interquartile range)

M = month

guidelines suggested by Root and Seigal and to keep the neck shaft angle at the time of the osteotomy below 115 degrees to avoid the recurrence of valgisation by anticipated remodeling.

Looking at the cases with a preoperative MI% 50 or more (16 hips), the containment grade after a 16 months period is shown in Table 8.

Out of the six poor results, four cases had a preoperative MI% of 60 -100 % with a high AI (> 30 degrees) raising the question of the need for a pelvic osteotomy to correct the acetabular dysplasia. In Song's series[20], he concluded that the incidence of postoperative hip instability was higher in the patients with preoperative femoral head uncoverage ranging from 30-70%. He suggested that in unstable hips with > 70% uncoverage of the femoral head, the patients should undergo a combined femoral and pelvic procedure. Hoffer[11] advocates a pelvic osteotomy if the acetabular index is > 30 degrees. In Noonan's series[21] of 73 hips operated by femoral varus derotation osteotomy followed up for an average of 5.2 years, he concluded that the age at which surgery is done and the degree of preoperative

Table 8: Showing 16/29 hips with MI% > 50% at preoperative assessment. Late postoperative MI% show 5/29 hips had a poor containment grade.

Case No.	Hip side	Migration % (preoperative)	Acetabular index	Migration % (Late post-operative)	grade
1.	R	70	**31**	0	G
3.	L	50	**30**	**35**	**P**
5.	R	50	27	17	F
6.	R	57	**31**	14	F
	L	81	**35**	19	F
8.	R	100	**35**	**27**	**P**
	L	100	**35**	**26**	**P**
9.	R	76	15	4	G
	L	76	15	4	G
12.	R	75	**36**	4	G
	L	55	**32**	6	F
13.	R	54	26	22	F
14.	R	100	**40**	**50**	**P**
15.	L	100	**33**	0	G
16.	R	64	**35**	**36**	**P**
17.	R	58	25	0	G

*Acetabular indices 30 degrees or more, Migration % > 25% and Poor grades are shown in bold

displacement had the most significant effects on outcome. Though we did not attempt to do a pelvic osteotomy in those patients with a poor uncoverage of the femoral head, we now feel that femoral varus derotation osteotomy alone is not enough to maintain hip stability in patients with high acetabular index and high preoperative migration index denoting a severe subluxation or complete dislocation.

CONCLUSION

Spastic cerebral palsy with hip subluxation may progress to complete dislocation. Femoral VDRO improves the containment of the hip and its stability on a short term basis. Remodeling at the osteotomy site may cause recurrence of the coxa valga especially in the younger age groups. This recurrence may affect the containment and stability of the hip especially in those patients with high MI% and high AI. To decrease this effect of remodeling of the osteotomy on the containment of the hip, the femoral neck shaft angle at the time of the osteotomy should be kept below 115 degrees. In patients with a high MI% and high AI, VDRO alone does not maintain the hip containment adequately.

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