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Roentgenographic Evaluation of Remodeling Potential in Developmental Dysplasia of Hip after Closed Reduction

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Abstract **Introduction** : We conducted this study to evaluate roentgenographically the hip remodeling in children with developmental dysplasia of hips(DDH) after closed reduction, and in attempt to reveal some of the possible predicting factors for the development of residual dysplasia.

Materials & Methods : Forty-six children with 50 hips received closed reductions following either by Pavlik harness, hip spica, or Scottish-Rite brace for a respective period of time. Roentgenographic studies of the acetabular indices(AI) and center-edge angles(CEA) were carefully assessed. The patients were divided into group A(residual dysplasia) and group B (well reduced hips), according to their final measurements. Statistics were done to compare patients with different results and with different age of treatment.

Results : The demographic data, including birth body weight, age at diagnosis, method of bracing, as well as the duration of treatment, were statistically insignificant between the two groups. After treatments, the AI averaged 33.4° and 28.8° with significant change of 1.1° and 5.3° respectively. This difference could still be noted after the treatments. Change in the CEA after treatments is also statistically significant.

Conclusion : The remodeling power in group A was much less than group B either during or after the treatment. Since there was no difference in the demographic data between the two groups, the genetic and biological factors may have also played a role for the poor remodeling power.

Introduction

Developmental dislocation of hip(DDH) is a fairly common disorder found in the children, with an incidence of 2 to 6 in every thousand population[6]. Degenerative changes in the hip joints may develop early in life if left untreated, and over 50% of the patients will eventually require reconstructive procedure before age of 60[7]. Early treatment can be done nonsurgically with promising results, however, there are still a good number of babies who are misdiagnosed until toddler and surgical interventions become inevitable.

In spite of early treatment with closed reduction, a fraction of the hips may still remain

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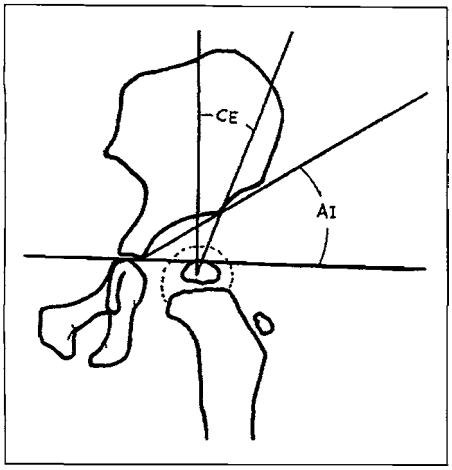

Fig. 1. Measurement of the AI and CEA.

stable but dysplastic, which is also one of the most common complications found, with reported incidence ranging from 15% to 40%[12)15)], nevertheless, there is yet no accurate radiographic parameter that is able to predict the outcome.

This is a retrospective study based on the long-term radiographic results of developmental dislocated hips after nonoperative treatment, in which the remodeling potentials as well as the demographic differences are thoroughly discussed.

Materials and Methods

We recruited 46 children having either unilateral or bilateral developmental dislocation of hips from 1990 to 1997, with a total number of 50 hips, and closed reductions were obtained either by Pavlik harness, hip spica, or Scottish-Rite brace for a period of one year.

Regular out-patient clinic follow-ups with regular roengenographic examinations were performed to ensure concentric reduction of the hips, and two parameters, the acetabular index (AI) and center-edge angle (CEA) (Fig. 1) were obtained from the standard antero-posterior radiographic films of pelvis.

Using the acetabular indices as the denominators, the patients were divided into two groups according to their final measurements. Group A represented the cases having either the final acetabular indices greater than 30°, or having the differences of the acetabular indices in both hips greater than 13°. This group was considered to have residual dysplasia. The remaining cases on the other hand, having well reduced hips with successful remodeling, were classified into group B. An average follow-up period of 42.8 months (10-87 months) was done.

Statistical analysis was performed using the statistical software package SPSS for Windows (Release 11.0, SPSS Inc.). Student-t test, ANOVA and χ^2 test were used to compare the difference among groups for discrete variable.

Results

Group A consisted of a total of ten hips (20%) that remained dysplastic, in which 30% were boys, as compared to only 5% in the group B. There was no difference among the birth body weight, the performance of adductor tenotomy, or the age at diagnosis. Although not statistically significant, there was a slight delay in the age at treatment and a decrease in the duration of bracing in the group A. The total duration of follow-up in the group A was less than that in the group B, but an average of 42.8 months was permitted. Additionally, we found a case of avascular necrosis in group A, and 12 cases in group B (Table 1).

The mean pretreated acetabular indices in the two groups were similar, with 34.6° in the group A, and 34.5° in the group B. However, significant differences between the acetabular indices, as well as center-edge (CE) angles, were noticeable upon completion of the treatments ; the average AI in the group A changed slightly

Table 1.
Basic patient data in group A and group B

	Group A	Group B	Total	P Value
No. of Cases	10	36	46	
Sex (M/F)	3/7	2/34	5/41	
Locations (Rt/Lt/Blt)	0/8/2	8/26/2	8/34/4	
Age of Treatment (Months)	13.2±5.44	11.8±5.97	12.1±5.80	0.870
Duration of Treatment (Months)	10.3±5.10	13.7±5.67	12.9±5.53	0.387
Duration of Follow Up (Months)	21.9±8.76	48.6±21.46	42.8±23.31	0.0004*
Avascular Necrosis	1	12	13	
Adductor Tenotomy	9	22	31	

to 33.4°, while that in the group B improved to 28.8°. Furthermore, remodeling process continued to take place in the group B, but nearly ceased in the group A, leaving a average final AI of 22.9° versus 33.0°. Overall, the changes of the AI in the group B was more than 7 times that in the group A. For the CE angle, the total changes in the group B was 4.3 times that in the group A, leading to a final average angle of 19.8° versus 5.4° (Table 2).

On the contralateral hip, excluding those patients with bilateral involvements, the changes in the AI were from 23.3° to 20.1° in the group A, and from 22.8° to 17.5° in the group B. Interestingly, although not statistically significant, the remodeling potential on the uninvolved hips seemed also less in the group A, and similar results were observed in the CE angles as well (Table 2).

When these patients were evaluated in respect to the ages at treatments, 12 patients (26%) received treatments before 6 months of age (group I), 10 patients (23%) at the age between 6 months to 12 months old (group II), and 24 patients (52%) started their treatments at an age over one year (group III). The results showed a 100% success when treated early before age of 6 months, but deteriorated with failures in one fourth to one third of cases if treated later (Table 3).

Analysis of the data showed significant difference between both hips among the three groups. Surprisingly, although all the patients in group I had successful results, the final AI in the dysplastic hip was significantly greater than that of the contralateral hip. Less correlation was noted for the CE angles (Table 4).

ANOVA Post Hoc test was performed for the three groups. We found no difference in the AI both before, and immediately after treatment. However, significant difference between group I and group II was noted in the final AI (Table 5).

Discussion

It is well accepted that the untreated or residual acetabular dysplasia leads to premature osteoarthritis of hip[11)20)21)], and early treatment warrants high rate of success, reaching 84% to 95.5% if started since birth[12)18)]. Nevertheless, not all the cases are detected early and different ages at treatment require individualized modalities, including surgeries.

Nonsurgical treatments are primary choices in early ages, but the upper age limit is unknown. Berkeley proposed an age of 14 months[1)], Weinstein suggested of 24 months of age[22)], but most authors, including Kalamchi, set the limit to 18 months, after which open reduction should be considered[8)].

Table 2. Results and comparisons in AI and CEA between group A and group B

	Affected Hip			Unaffected Hip		
	Group A	Group B	P Value	Group A	Group B	P Value
Pre Treated AI(°)	34.6±6.43	34.5±4.42	0.936	23.3±4.30	22.8±5.63	0.808
Post Treated AI(°)	33.4±4.36	28.8±4.37	0.007*	22.3±4.50	20.9±4.63	0.454
Change during Treatment	1.1±6.35	5.3±4.23	0.023*	1.4±2.65	2.1±5.35	0.729
Change after Treatment	0.2±3.31	5.9±3.98	0.002*	2.7±5.50	3.2±4.07	0.799
Final AI(°)	33.0±3.86	22.9±3.97	0.000*	20.1±4.41	17.5±3.96	0.080
Total Change AI(°)	1.6±5.21	11.6±5.21	0.000*	3.2±3.49	5.3±5.38	0.249
Pre Treated CEA(%)	NA	NA		NA	NA	
Post Treated CEA(%)	3.3±9.92	11.7±6.52	0.005*	18.6±7.25	17.5±6.06	0.651
Final CEA(%)	5.4±10.27	19.8±6.69	0.000*	19.1±7.4	23.2±6.48	0.091
Total Change CEA(%)	2.4±6.59	9.4±8.31	0.018*	2.4±8.57	7.7±9.47	0.118

*t Test analysis with significant difference ($P<0.05$)
NA : not available

Table 3. Basic patient data in different age-groups

	Group I	Group II	Group III
Age of Treatment(Months)	<6	6 12	>12
No. of Cases	12	10	24
Sex(M/F)*	0/12	2/8	3/21
Locations(Rt/Lt/Blt)	3/8/1	1/6/3	4/20/0
Age of Treatment(Months)*	3.7±1.37	11.8±5.97	12.1±5.80
Duration of Follow Up(Months)*	49.31±23.22	29.85±8.24	44.86±24.28
No. of Residual Dysplasia	1	1	5

*ANOVA resulted no statistical significance

The potential complications following the treatments of developmental dislocation of hip are avascular necrosis, residual subluxation, and dysplasia, with a range from 6% to 65.8%[3)5)7)10)13)24)], and most of these cases eventually will require secondary surgical procedures. Therefore, it is imperative to recognize early signs of these squeals, and to take necessary actions as soon as possible.

The key to successful treatment is to obtain a prompt and adequate remodeling of the hip, which requires accurate image studies to monitor. Computed tomography(CT) is a good method to assess the acetabular contour as well as its relationship to the femoral head[4)17)], and the three dimensional images provide even better resolution for the anterior deficiency of the acetabulum[9)], but it is impractical and hazardous for routine follow-ups. The plain radiography of the pelvis remains the most efficient modality in terms of its accessibility and the cost-effectiveness, specially after the 3-6 months of age[6)], and different parameters can be used as a guide to monitor its development.

Several parameters from the plain films have been used to predict and monitor the results after treatments, with each indicating a specific area of development of the acetabulum, but none has been widely accepted. The acetabular index has been reported, in many works, to signify a good prognosis with a decline of 10° in the first year[14)16)19)], however, Brougham has found it to be unreliable[2)]. Murphy feels that the center-edge angle is a fairly sensitive indication

Table 4. Results and comparisons in AI and CEA between three age-groups

	Group I			Group II			Group III		
	Affected Hip	Unaffected Hip	P-value	Affected Hip	Unaffected Hip	P-value	Affected Hip	Unaffected Hip	P-value
Pre-Treated AI	32.6±3.68	22.4±4.66	<0.001*	37.2±5.47	25.7±8.02	0.002*	34.3±4.81	22.0±3.86	<0.001*
Post-Treated AI	29.2±3.52	23.0±3.13	0.001*	31.8±3.62	22.3±5.83	<0.001*	29.1±5.55	19.9±4.23	<0.001*
Final AI	22.5±4.50	18.0±3.28	<0.001*	29.1±4.43	21.5±4.60	0.001*	24.8±6.04	16.7±3.63	0.010*
Total Change AI	11.5±3.56	5.8±3.12	0.001*	8.1±4.93	7.8±6.27	0.85	11.2±5.31	6.1±3.80	<0.001*
Post-Treated CEA	8.0±5.81	13.6±5.64	0.043*	8.6±6.47	17.0±6.55	0.010*	11.3±9.53	20.0±5.53	0.001*
Final CEA	20.3±7.01	21.6±6.45	0.654	12.7±6.23	17.1±5.34	0.108	16.5±11.29	24.9±6.42	0.003*

*t-Test with significant difference

Table 5. ANOVA post hoc test between different age-groups

		Group I			Group II			Group III		
		Pre-Treated AI	Post-Treated AI	Final AI	Pre Treated AI	Post Treated AI	Final AI	Pre Treated AI	Post Treated AI	Final AI
Affected Hip	Group I				0.079	0.676	0.019*	0.923	1.000	0.727
	Group II	0.079	0.676	0.019*				0.329	0.431	0.111
	Group III	0.923	1.000	0.727	0.329	0.431	0.111			
Unaffected Hip	Group I				0.448	1.000	0.107	1.000	0.239	0.969
	Group II	0.448	1.000	0.107				0.205	0.514	0.114
	Group III	1.000	0.239	0.969	0.205	0.514	0.114			

*Statistical Significance($P<0.05$)

of dysplasia of the hip[11], yet Weintroub disagrees on that point of view, especially in the children younger than 3 years of age[23]. We have tried to use the two parameters for evaluation, and have noticed that the acetabular index is more consistent in the measurements ; the CE angle depends greatly on the position of the hip and the inclination of the pelvis when the film is being taken, since it is the relationship between two separate components.

The remodeling power, in our cases, is seen to be the greatest at the very beginning of treatment, and declined in a steep pace at age between two and half to three years, which explains the high failure rate in late treatment. For those children who failed conservative treatment, the difference in the amount of remodeling is noted as early as immediately after the treatment, and the remodeling seems to continue for the group B, but nearly ceases for group A, even during the time without bracing. On the intact hip, there is no significant difference between the both groups during the entire length of follow-up. Although less consistent values are noted in the CE angles, similar trend is also noted.

From table 4, significant differences are noted in the AI between dysplastic and contralateral hips in all groups also throughout the entire length of follow-up, therefore, we conclude that in spite of well reduction and remodeling, the final AI is still significantly different from the contralateral hips, implying an inherent factor affecting the extend of

remodeling.

Unfortunately we find no much significance whether to start treatment early or late, however, we still agree that treatment should be carried out as early as possible, and the main reason for our results could be due to insufficient case numbers.

In conclusion, residual dysplasia of hips after closed reduction is not uncommon, and one should be well aware of the fact in order to carry out with appropriate intervention at the best time period. No responsible factor is discovered for the cause of residual dysplasia, and inherent factor is most favored, however, further study shall be carried out.

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