

## Original Article

# Clinical study on salter innominate osteotomy for developmental dysplasia of hip in children

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**Abstract:** Objectives: This is to analyze the clinical effect of Salter Innominate Osteotomy on developmental dysplasia of hip (DDH) in children and the correlation between clinical variables before and after operation and adverse reactions. Methods: Retrospective analysis was adopted to analyze the efficacy of Salter Innominate Osteotomy on developmental dysplasia of hip in eighty children admitted to Henan Luoyang Orthopedic Hospital (Henan Provincial Orthopedic Hospital). According to the percentage of femoral head not covered by acetabulum within 6 months after surgery, these patients were divided into five groups. The differences of acetabular index, wiberg central-edge angle and the occurrence of adverse reactions were contrasted among the five groups. Results: Fine rate of Salter Innominate Osteotomy on DDH in children was more than 90%. And three patients had adverse reactions. Femoral head coverage of acetabulum was closely related to acetabular index before surgery. Conclusions: The incidence of adverse reactions after Salter Innominate Osteotomy was low. Preoperative and postoperative acetabular index, wiberg central-edge angle, femoral head coverage ratio and other indexes had a certain correlation with postoperative adverse reactions.

**Keywords:** Developmental dysplasia of the hip in children, salter innominate osteotomy, clinical study

## Introduction

Developmental dysplasia of hip (DDH) is a common disease in pediatric orthopedics. If children with DDH are not treated with correct therapy in time, they will suffer from dysfunction of the hip joint and early degenerative osteoarthritis, even soft tissue dysplasia in acetabulum, femoral head, femoral neck bone structure, joint capsule, ligamentum teres and muscles around joints. In 1961, Slater adopted innominate osteotomy at first to treat acetabular dysplasia of DDH and subluxated dislocation. At present, Salter Innominate Osteotomy has been widely applied to the treatment of DDH in children [1]. However, some patients are accompanied by different degrees of adverse reactions in postoperative recovery [2, 3]. Therefore, recovery evaluation and adverse reaction after Salter Innominate Osteotomy are always the focus of clinical research.

The important parameters to evaluate the effect of Salter Innominate Osteotomy include

acetabular index (AI), wiberg central-edge angle (CE angle), femoral head coverage, etc. At the same time these indexes are the hint to remind whether patients have adverse reactions after surgery. In order to analyze the effect of acetabular index and wiberg central-edge angle on the femoral head coverage after operation and the relationship between these indexes and postoperative adverse reactions, retrospective analysis was adopted to this study. According to the grade of postoperative femoral head coverage, patients were grouped. This research analyzed the clinical data of 80 patients with DDH treated with Salter Innominate Osteotomy.

## Material and methods

### Subjects

The patients with DDH admitted in Henan Luoyang Orthopedic Hospital (Henan Provincial Orthopedic Hospital) from 2009 to 2015 were treated with Salter Innominate Osteotomy. Patients with hip dysplasia, paralysis,

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**Table 1.** Patients' clinical follow-up results after Salter innominate osteotomy (Mckay criteria)

Degree	Criteria	Number of cases	Percentage
Excellent	Hip without pain; free from claudication; normal activity in hip joint	73	76.8%
Good	Hip without pain; slight claudication; slightly limited activity in hip joint	17	17.8%
Moderate	Hip without pain; with claudication; obviously limited activity in hip joint; trendelenburg (+)	5	5.4%
Bad	Hip with pain; severe claudication; obviously limited activity in hip joint; trendelenburg (+)	0	0

**Table 2.** X-ray follow-up results of patients after Salter innominate osteotomy (Severin criteria)

Degree	Criteria	Number of cases	Percentage
Excellent	Femoral head with normal shape; the CE angle > 25°	70	73.7%
Good	Moderate deformation of femoral head; center reduction; the CE angle > 25°	18	18.9%
Moderate	Acetabular dysplasia; continuous Shenton lines; the CE angle < 20°	7	7.4%
Bad	Subluxation of hip; discontinuous Shenton lines or redislocation of hip	0	0

**Table 3.** The preoperative and postoperative acetabular index and CE angle comparison in five groups

Level	N	Acetabular index		CE angle	
		Preoperation	Postoperation	Preoperation	Postoperation
0 level	15	33.2±3.6 <sup>b</sup>	21.0±3.1	1.5±2.3 <sup>b</sup>	19.2±3.2
I level	23	32.7±3.9 <sup>b</sup>	21.7±3.0	1.1±2.0 <sup>b</sup>	17.9±3.0
II level	21	33.9±4.0 <sup>b</sup>	22.6±2.9	0.8±2.1 <sup>b</sup>	15.4±2.7
III level	20	34.1±3.4 <sup>b</sup>	22.8±3.2	-0.2±2.7 <sup>b</sup>	16.0±2.9
IV level	16	35.6±4.3 <sup>a,b</sup>	23.1±3.0	-0.9±3.4 <sup>a,b</sup>	15.0±3.4
P		0.002	0.079	0.062	0.024

Note: the analysis of variance was applied to take multigroup comparison; LSD method was applied to take pairwise comparison; paired t test was applied to take preoperative and postoperative comparison. a: compared with 0 level and IV level, the differences had statistical significance, P < 0.05 (pairwise comparison with LSD method); b: compared with preoperation and postoperation, the differences had statistical significance, P < 0.05 (paired t test).

infection as well as patients lost in the follow-up were excluded. A total of 95 hips of 80 patients who met the requirement of grouping were randomly collected. Among these patients, male were 31 accounting for 38.7%, 49 female accounting for 61.3%, mean age with 5.6±2.5 years old (ranging 2-9 years old); 45 diseased left hips accounting for 47.3%, 50 diseased right hips accounting for 52.7%; average duration of follow-up was 15.5 months.

### Grouping

According to the percentage of femoral head uncovered by acetabulum in six months after operation, patients' stunted conditions after operation were divided into five levels [4]. 0 level: no dislocation; I level: 30% subluxation; II level: 30-60% subluxation; III level: 60-90%

subluxation; IV level: complete dislocation. According to these levels, the eighty patients were divided into five groups. 15 hips were in 0 level, 23 in I level, 21 in II level, 20 in III level, and 16 in IV level.

### Imaging materials

Before operation and six months after operation, patients' x-ray films of pelvis ap were taken, and acetabular index (AI) and CE angle were made by imaging measurement. In six months after operation, x-ray radiographs and CT scanning were taken; percentage

of femoral head uncovered by acetabulum of patients with DDH was calculated; patients were graded according to the above standards. In the final follow-up, postoperative effect was evaluated by Severin imaging rating standards and McKay functional rating standards.

### Statistical analysis

SPSS 18.0, the statistical software, was adopted to statistical analysis. Measurement data were showed as mean ± standard deviation (x±s). ANOVA was applied to comparison among groups. LSD method was applied to taking pairwise comparison. Paired t-test was applied to taking preoperative and postoperative comparison of acetabular index and CE angle. The differences had statistical significance with P ≤ 0.05.

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**Table 4.** Basic information of patients with redislocation

Patients ID	Level	Age	Acetabular index		CE angle	
			Preoperation	Postoperation	Preoperation	Postoperation
1	III level	7 years old 6 months	35.5	24.9	0.6	12.3
2	IV level	9 years old 1 month	37.6	25.3	-0.5	10.2
3	IV level	9 years old 9 months	38.7	24.6	-0.2	10.6

### Results

#### *Clinical effect assessment after salter innominate osteotomy*

In the final follow-up, most patients' flexional degree of the hip joint in affected side reached or approached the degree in unaffected side. In affected side, the extending, adduction, and abduction of hip and activity of extorsion in hip flexion returned normal. According to McKay criteria, the results of clinical follow-up after operation showed in **Table 1**. The results of follow-up showed that the postoperative qualified ratio of patients was 94.6%. According to Severin criteria, the results of X-ray checking follow-up results showed in **Table 2**. The results of follow-up showed that there was no patient with subluxation and dislocation of hip after operation, and the qualified ratio was 92.6%.

#### *Acetabular index and CE angle comparison of patients in all groups before and after operation*

The details of comparison showed in **Table 3**. Eighty cases were taken Salter innominate osteotomy six months ago. At present, according to the percentage of femoral head uncovered by acetabulum, there are 15 hips in patients with no dislocation (0 level), 23 hips in 30% patients with subluxation (I level), 21 hips in 30-60% patients with subluxation (II level), 20 hips in 60-90% patients with subluxation (III level), and 16 hips in patients with complete dislocation (IV level). Paired T test was applied to comparison acetabular index and CE angle of patients in all groups before and after operation, and the differences had statistical significance ( $P < 0.05$ ). The acetabular index reduced from  $33.6 \pm 5.1$  before operation to  $22.3 \pm 4.3$  after operation; the CE angle recovered to  $16.6 \pm 4.0$  after operation from  $0.58 \pm 3.2$  before operation.

The analysis of variance was also applied to comparison patients' acetabular indexes and

CE angles among groups. The results showed that it had obvious differences. By pairwise comparison, the differences of preoperative acetabular index between patients with no dislocation group (0 level) and patients with complete dislocation group (IV level) had statistical significance ( $P < 0.05$ ). Preoperative acetabular index of patients in no dislocation group was  $33.2 \pm 3.6$ . Preoperative acetabular index of patients in complete dislocation group was  $35.6 \pm 3.4$ , which was the biggest among groups. And also, postoperative acetabular index of patients in complete dislocation group had the biggest mean among groups. In postoperative follow-up, there were 2 cases in complete dislocation group suffering from redislocation during postoperative recovery, 1 case in III level group (60%-90% subluxation group) suffering from redislocation, and there was no adverse reaction, such as femoral head necrosis, and arthritis in early phase. The detail information of patients with redislocation showed in **Table 4**.

### Discussion

From **Tables 1** and **2**, Salter innominate osteotomy had high curative effects for child with DDH. The overall excellent and good rates were above 90%. Salter innominate osteotomy is mainly suited to patients between 2 and 6 years old, which could correct abnormally acetabular direction, diminish acetabular index, enlarge CE angle, improve adaptation among femoral heads, and increase the stability after restoration [5]. Acetabular index (AI) is the most classic indicator to measure operation results. Postoperative descending degree of AI is closely related to prognosis. Mean AI of normal newborn infant is  $27.5^\circ$ . After 1 year old, AI is less than  $25^\circ$ . In 2 years old, it drops to  $20^\circ$ . The change of AI after operation could reflect the change of acetabular shape. After operation AI of 80 cases averagely decreased  $11^\circ$ . The normal range of CE angle is  $20^\circ$ - $40^\circ$  inward. The smaller the CE angle is, the more instable the

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hip joint will be. CE angles of 80 cases notably improved after operation, which grew to around 16° from approaching to the minus value.

Femoral head coverage rate of acetabulum could visually display the shape and development of acetabulum. In fetus and newborn period, they have lower acetabulum and lower coverage rate with averagely 65%. In 4-5 years old, their coverage rate is about 70%, which approaches to the rate of normal adults. Femoral head coverage rate in acetabulum of patients with DDH was somewhat increased after Salter innominate osteotomy. Significant change of femoral head coverage rate in acetabulum of patients had happened in the first year after operation, which is the critical period to develop acetabulum. Within four years, it would gradually recover [5-8]. In our research, among 80 cases there were 3 cases happened redislocation after Salter innominate osteotomy, 1 case in III level group, 2 cases in IV level group, and other groups without adverse reactions. It showed that the lower the femoral head coverage rate in acetabulum after operation was, the greater the risk of redislocation would be. At the same time, both the preoperative and postoperative AIs of the 3 cases were higher than the mean of each group. CE angles after operation were lower than the mean in each group, which showed that the 3 cases' hip joints were unstable and easy to dislocate compared with other patients. Another interesting phenomenon was that when patients' acetabulum had higher femoral head coverage rate after operation, AI had the trend of decreasing, and CE angle had the trend of increasing. By measuring 97 cases with acetabular dislocation, Taketa, et al. [9] also had approved a correlation between femoral head coverage rate and CE angle. By imaging analysis, Yuguang Wang [10] also found a negative correlation between cartilage AI and femoral head coverage rate of patients' DDH. The more close the AI was, the better the femoral head coverage rate of acetabulum would be. In addition, age also could be one reason to make patients suffering from dislocation [11].

In conclusion, adverse reactions still existed in Salter innominate osteotomy. How to prevent adverse reaction according to some indexes, such as preoperative and postoperative AI, CE angle, and femoral head coverage rate of ace-

tabulum, and the underlying correlation among indexes is still a valuable research topic.

### Disclosure of conflict of interest

None.

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### References

- [1] Böhm P, Brzuske A. Salter innominate osteotomy for the treatment of developmental dysplasia of the hip in children. *American Journal of Psychiatry* 2013; 91: 869-880.
- [2] Kaneko H, Kitoh H, Mishima K, Matsushita M, Kadono I, Ishiguro N, Hattori T. Factors associated with an unfavourable outcome after Salter innominate osteotomy in patients with unilateral developmental dysplasia of the hip: does occult dysplasia of the contralateral hip affect the outcome? *Bone Joint J* 2014; 96-B: 1419-23.
- [3] Zhang Z, Yang J, Gong R, Fu Z, Deng S. Long term results of open reduction and Salter Innominate Osteotomy for Developmental dysplasia of the hip in children. *Chinese Journal Of Orthopaedics* 2014; 34: 1183-1189.
- [4] Fakoor M, Aliakbari A, Javaherizadeh H. Study of acetabular index before and after salter innominate osteotomy. *Pakistan Journal of Medical Sciences Online* 2011; 27: 557-560.
- [5] Jiang J, Ren S, Liu M. Impact of salter innominate osteotomy on acetabular morphology and direction in Developmental dysplasia of the hip ba three-dimensional computer tomography. *Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi* 2015; 29: 1332-1336.
- [6] Hu GF, Qian PY, Ding GL, Qian B, Hu XH, Wu JT. Mean femoral head coverage rate in acetabulum of patients with developmental dysplasia of the hip measured by three-dimensional CT reconstruction. *Chinese Journal of Tissue Engineering Research* 2012; 7288-7291.
- [7] Ku JB, Guo XH, Diao XC, Liu X. CT observation on mean femoral head coverage rate in acetabulum of patients with developmental dysplasia of the hip after closed reduction. *Journal of Hebei Medical University* 2013; 34.
- [8] Ganger R, Radler C, Petje G, Manner HM, Kriegs-Au G, Grill F. Treatment options for Developmental dysplasia of the hip after walking age. *J Pediatr Orthop B* 2005; 14: 139-50.

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- [9] Taketa M, Fujii T, Kubota H, Nakashima Y, Noguchi Y, Iwamoto Y. Correlation between center-edge angle and acetabulum-head index in developmental dysplasia of the hip with avascular necrosis of the femoral head. *J Pediatr Orthop B* 2003; 12: 215-218.
- [10] Wang YG. Imaging analysis on acetabular index and femoral head coverage rate. Inner Mongolia Medical College 2009.
- [11] Zhu Z, Xuemin L, Bian Z, Yang J. Treatment strategy and clinical outcome of Developmental dysplasia of the hip in children above 8 years old. *Chinese Journal of Orthopaedics* 2014; 34: 1175-1182.