



## Age and Factors Associated with Clinical and Radiological Outcomes of Surgical Containment in Legg-Calve-Perthes Disease

Varinthorn Adulyanukosol, MD, Supphamard Lewsirirat, MD, Guntarat Chinvattanachot, MD

Department of Orthopedic Surgery, Maharat Nakhon Ratchasima Hospital, Nakhon Ratchasima, Thailand

**Purpose:** To determine the factors associated with clinical and radiological outcomes in patients with Legg-Calve-Perthes disease (LCPD) treated with containment methods.

**Methods:** This retrospective cohort study was conducted from 2007 – 2017. Patients diagnosed with LCPD in the fragmentation stage and treated using surgical containment methods were included. Study factors were age at diagnosis, preoperative radiographs analyzed for lateral pillar staging and Catterall classification. Outcome measurements were final follow-up radiograph, classified using modified Stulberg grading, and final clinical outcome, classified by Harris Hip Score.

**Results:** We analyzed 44 hips. The average age of subjects during diagnosis and follow-up was 8.1 and 12.7 years, respectively. The average length of follow-up was 58.6 months. Nineteen hips were evaluated as “good” (Stulberg I or II), 22 hips as “fair” (Stulberg III), and four hips as “poor” (Stulberg IV); no hips were classified as Stulberg V. Although not significant, the combination of Salter osteotomy and femoral varus osteotomy yielded better outcomes than varus osteotomy alone in the group >8 years old ( $p=0.247$ ). The median age of 7 (7 – 8) years old was correlated with “good to excellent” Harris Hip Score while median age of 9 years was significantly correlated with the score of “fair” and “poor” ( $p=0.018$ ). Lateral pillar A and B yielded significantly better results than lateral pillar C ( $p=0.014$ ).

**Conclusion:** The containment methods demonstrated favorable outcomes when treating patients < 9 years. Lateral pillars A and B had good end results. Combined pelvic and femoral osteotomy can improve radiographic and clinical outcomes.

**Keywords:** Legg-Calve-Perthes disease, containment, factor, age, outcome

Legg-Calve-Perthes disease (LCPD) is a childhood and juvenile hip disease of unknown etiology which causes interruption in the blood supply, and eventually leads to avascular necrosis of the femoral head<sup>(1)</sup>. Subsequently, it may cause

femoral head deformity and joint incongruency<sup>(2)</sup>. The principle of treatment is to protect the softened femoral head (biologic plasticity)<sup>(1)</sup> from deforming force until it reforms to achieve a congruent mobile hip joint<sup>(3)</sup>.

Containment methods hold the femoral head in the acetabulum to prevent progressive femoral head lateral subluxation during femoral head remodeling<sup>(3)</sup>. Surgical procedures in containment methods include proximal femoral varus osteotomy, Salter innominate pelvis osteotomy, or a combination of femur and pelvic procedures<sup>(3,4)</sup>. The proximal femoral varus osteotomy aims to improve containment between the femoral head

### Article history:

Received: October 17, 2021 Revised: February 15, 2022

Accepted: March 18, 2022

Correspondence to: Varinthorn Adulyanukosol, MD  
Department of Orthopedic Surgery, Maharat Nakhon Ratchasima Hospital, Nakhon Ratchasima, Thailand  
E-mail: loogbat@hotmail.com

and acetabulum. However, this may cause leg shortening, hip abductor weakness, or varus deformity<sup>(2)</sup>. The Salter osteotomy, however, does not lead to shortening of the leg but may increase the pressure on the femoral head<sup>(5)</sup>.

For patients who are 9 years of age or older, non-containment methods, such as lateral shelf acetabuloplasty and valgus osteotomy, are employed because it is unlikely that biologic plasticity in older patients will be re-modeled to form a well-functioning congruent hip. Nevertheless, there are still controversies regarding the optimal age range and treatment type that is most suitable for older patients<sup>(5,6)</sup>. This study was aimed to assess age and other factors associated with radiological outcomes of surgical containment methods in LCPD.

## MATERIALS AND METHODS

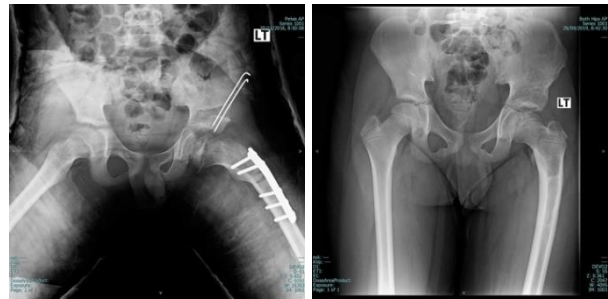
### Patient Population

A retrospective cohort study was conducted at our institution from 2007 to 2017. The inclusion criteria were LCPD treated by femoral varus osteotomy alone or combined with Salter osteotomy and availability of data, such as radiographic and clinical outcomes. Patients who underwent a different treatment or had developmental hip dysplasia were excluded. This study was approved from the local ethical research committee.

### Surgical Procedure and Pre- and Postoperative Protocol

All patients were admitted preoperatively and underwent bed rest and ROM exercise. The indication must be lateral pillar B, B/C or C in aged more than 6 years old, having full hip range of motion, and hip congruency detected by hip arthrogram. The main surgical treatment was femoral varus osteotomy. If the hip containment required more than 20-degree hip abduction, the combined procedure was performed to minimize an adverse effect from excessive femoral varus osteotomy, i.e. limb shortening. For proximal femoral varus osteotomy, a lateral approach with a saw was used to cut the bone at proximal femur, and a small or narrow dynamic compression plate was used for fixation. In the Smith-Petersen

approach for pelvic osteotomy, an iliac wing triangular bone graft and fixation with smooth Kirchner wires or screws were utilized as [figure 1](#). All patients underwent rehabilitation for hip range of motion improvement. Postoperatively, the patients used crutches for 8 weeks and gradually increased their range of motion, particularly abduction.



**Fig. 1.** A nine-year-old boy treated with combination of pelvis and femoral osteotomy.

### Statistical analysis

Using the 'Power and Sample-Size' program, the sample size was calculated with a 5 percent alpha, an 80 percent power, and a 1:1 ratio of independent exposed and unexposed groups. From a study by Mosol et al.<sup>(2)</sup>, we used 90 and 50 percent of the proportion of good and excellent outcomes in patients aged under 8 years old and more than 8 years old, respectively. The computed sample size revealed that a sample size of 38 was appropriate. The estimated loss due to follow-up was 10%. This study comprised at least 42 patients.

Data were analyzed using SPSS version 25 (IBM Corp., Armonk, N.Y., USA). The mean and SD were reported for continuous data with a normal distribution, while the median and interquartile range were presented for non-normally distributed data. For categorical data, the proportion was reported. To compare categorical outcomes, the chi-square test was used. To compare continuous data with a normal distribution, the student T-test was utilized. To compare non-normally distributed data, the Mann-Whitney test was used, and P 0.05 was considered statistically significant. Univariable and multivariable analyses were performed using logistic regression between clinical outcome and prognosis factors. In the multivariable analysis,

based on the hypothesis of the study manual selection factor was used. The type of surgery, age group and potential prognosis factor that P values less than 0.1 on univariable analysis are considered for inclusion in the model. Odds ratios with 95% confidence intervals (C.I.) were used to evaluate the direction and strength of associations. We checked the presence of interaction effects between independent variables, performed an overall model evaluation, statistical test of individual predictors, and goodness-of-fit statistics of the model. The level of P value less than 0.05 will be considered as statistical significance.

### Outcome Measures

The Harris Hip Score was used for clinical evaluations, such as activities of daily living, pain level, and hip function, by two independent pediatric orthopedic surgeons<sup>(7-10)</sup>. Radiological evaluations were obtained preoperatively from the lateral pillar and the Catterall classification and from the Stulberg classification during the follow-up period<sup>(4,11,12)</sup>. The treatment at different stages demonstrated different results: stage 1 or 2, good; stage 3, fair; and stage 4 or 5, poor<sup>(1)</sup>. The mean Harris hip score was categorized as excellent (90 – 100), good (80 – 89), fair (70 – 79) and poor (<70). The results classified as fair, good, and excellent were regarded as “efficacious”. To ensure maximum accuracy, two pediatric orthopedic surgeons independently evaluated the radiographs<sup>(14)</sup>.

## RESULTS

This study included 44 patients (44 hips) diagnosed with LCPD in the fragmentation stage, who were treated using surgical containment methods. Fourteen patients were treated by proximal femoral varus osteotomy and 30 patients were treated by Salter osteotomy combined with proximal femur varus osteotomy. There were 34 males and 10 females. The average age of patients during diagnosis was 8.1 years (range 6 – 15). Twenty-nine patients had left hip pathology (66%). The average age of the patients at the last follow-up was 12.7 years (range 9 – 22). The average length of follow-up was 58.6 months (range 36 – 166) (Table 1).

**Table 1** Demographic data.

Characteristic	Number of patients
Gender	
Male	34 (77.3%)
Female	10 (22.7%)
Side	
Left	29 (65.9%)
Right	15 (34.1%)
Lateral pillar classification	
A	3 (6.8%)
B	14 (31.8%)
B/C	27 (61.4%)
C	-
Catterall classification	
1	-
2	8 (18.2%)
3	19 (43.2%)
4	17 (38.6%)
Stulberg classification	
1	4 (9.1%)
2	14 (31.8%)
3	22 (50%)
4	4 (9.1%)
5	-
Surgical procedure	
VDRO	14 (31.8%)
VDRO + Salter osteotomy	30 (68.2%)
Harris hip score	
Excellent	11 (25%)
Good	19 (43.2%)
Fair	12 (27.3%)
Poor	2 (4.5%)
Mean age at diagnosis (years)	8.1 (6-15)
Mean age at follow-up (years)	12.7 (9-22)
Mean follow-up period (months)	58.7 (36-166)

VDRO: Varus derotation osteotomy of the proximal femur

In the final examination, 19 hips were evaluated as “good” (Stulberg I or II), 22 as “fair” (Stulberg III), and four as “poor” (Stulberg IV); no hips meet the criteria for Stulberg V (Table 2). Five hips were classified as lateral pillar C and Stulberg I or II at the final follow-up; the age range of this group was 7 – 9 years; four of these were treated using the combined method (Table 3). The combination of pelvic and femoral osteotomy yielded better outcomes than proximal femoral osteotomy alone in patients older than 8 years (Table 4) but this was not significant (adjusted odds ratio 0.39, 95% confidence interval [CI] 0.08 – 1.92, p=0.247). In the same age group, lateral pillar A and B yielded

significantly better outcomes than lateral pillar C (odds ratio 11.89, 95%CI 1.31 – 108.08, p=0.028).

**Table 2** Stulberg classification according to lateral pillar classification.

Stulberg Classification	Lateral pillar A	Lateral pillar B	Lateral pillar C	Total
Stulberg I	2	1	1	4
Stulberg II	1	9	4	14
Stulberg III	0	4	18	22
Stulberg IV	0	0	4	4
Stulberg V	0	0	0	0
Total	3	14	27	44

**Table 3** Mean Harris hip score distribution according to lateral pillar classification.

Mean Harris hip score	Lateral pillar A	Lateral pillar B	Lateral pillar C	Total
Excellent	3	6	2	11
Good	0	7	12	19
Fair	0	1	11	12
Poor	0	0	2	2
Total	3	14	27	44

**Table 4** Surgical treatment distribution according to Stulberg classification.

	Stulberg I	Stulberg II	Stulberg III	Stulberg IV	Stulberg V
VDRO (n=14)	2	2	8	2	-
VDRO + Salter (n=30)	2	12	14	2	-

**Table 5** Factor distribution according to mean Harris hip score.

Factor	Mean Harris hip score		p-value
	Excellent and good Good outcome (n=30)	Fair and poor Poor outcome (n=14)	
Median age at diagnosis	7 (7-8)	9 (8-10)	0.018
Median follow-up	46 (41-66)	47 (40-87)	0.737
Median age at follow-up	12 (11-13)	13.5 (12-16)	0.002
Sex (male)	23 (77.67%)	11 (78.57%)	0.888
Side (right)	9 (30%)	6 (42.86%)	0.402
Age >8 years	13 (43.33%)	11 (78.57%)	0.029
Lateral pillar C	14 (46.67%)	13 (92.86)	0.013
VDRO	7 (23.33%)	7 (50%)	0.077
VDRO + Salter	23 (76.67%)	7 (50%)	0.068

**Table 6** Factors correlation with Harris Hip Score (odds ratio).

Factor	Odds ratio (95%CI)	p-value
Side		
Right vs left	0.57 (0.15-2.13)	0.183
Sex		
Male vs female	0.90 (0.19-4.15)	0.888
Age more than 8 years		
>=8 vs <8	0.21 (0.05-0.9)	0.036
Lateral pillar classification		
A,B vs B/C,C	14.86 (1.72-128.41)	0.014
Type of surgery		
VDRO vs combined	0.30 (0.08-1.17)	0.083

From [Table 5](#), the Mann–Whitney test showed that the median age of 7 (7 – 8) years was correlated with a Harris hip score of “good” or “excellent”; whereas, the median age of 9 years was correlated with a Harris hip score of “fair” or “poor” (p=0.018). From [Table 6](#), the lateral pillar A and B yielded significantly better results than lateral pillar C (14.86, 95%CI (1.72 – 128.41), p=0.014).

## DISCUSSION

At present, the surgical treatment, and types of surgery for LCPD remain controversial. The optimal age or stage of disease that is most appropriate for containment methods also remains debatable<sup>(2)</sup>. First described in 1952, proximal femoral varus osteotomy may cause shortening and limping<sup>(14)</sup>. However, the combination of proximal femoral varus and innominate osteotomies may reduce limb shortening because a smaller portion of the proximal femur needs to be cut to contain the femoral head<sup>(15)</sup>. This combined treatment method is likely to reduce intra-articular pressure from Salter osteotomy and prevent excessive shortening from femoral osteotomy<sup>(10)</sup>. It was found that combined osteotomies yielded significantly better treatment outcomes than femoral osteotomy alone, especially in older children<sup>(5)</sup>.

Among 44 patients (44 hips) with a mean age of 8.1 years during diagnosis, 30 hips (68%) showed excellent and good radiographic outcomes after treatment with containment methods. In other studies, the Stulberg classification classified stage I or II as “good”, stage III as “fair”, and stage IV or V as “poor” where good and fair results were

regarded as efficacious<sup>(1)</sup>. This study showed that the treatment outcome was efficacious for 42 hips, representing 95% of all treatment cases. Same the study by Eamsobhana, et al., from Siriraj hospital that reference Thai population conclude the combined osteotomy is safe and effective procedure for severe LCPD patient<sup>(16)</sup>. Compared to the study by Yavuz, et al., our study had a larger sample size (18 hips vs. 44 hips) and found more favorable outcomes in patients <9 years old with combined pelvic and femoral osteotomies<sup>(1)</sup>.

Our results also showed that patients aged ≤8 years who were treated using the containment method showed good treatment results. Although patients aged ≥9 years did not have treatment outcomes that were as good as the younger group, the treatment outcomes were still considered favorable. Therefore, with regards to radiographic and clinical outcomes, patients in the younger group (8 years or younger) showed significantly better results than those of the older group (9 years or older). This finding corresponds to other studies where pre-operative radiographic lateral pillar A and B yielded significantly better end results than lateral pillar C<sup>(1,3)</sup>. Radiographic classifications, such as lateral pillar, Catterall, and Stulberg classifications, showed results corresponding with other studies.

This study has some limitations: its retrospective nature, the inclusion of patients with missing follow-up sessions and incomplete data collection. Further prospective long-term studies are needed to decrease the limitation. Though a larger sample size may have made the results more reliable and produced slightly different results, this sample size represented the largest number of patients who were treated with containment methods for LCPD in a single institution in Thailand. We suggest in LCPD patient with age < 9 years old can be treated with combined pelvic and femoral osteotomies for favorable outcomes.

## CONCLUSION

The treatment of LCPD with containment methods showed favorable outcomes in patients younger than 9 years old. Pre-operative radiographic lateral pillar A and B yielded significantly better

end results than lateral pillar C. The combination of pelvic osteotomy and proximal femoral varus osteotomy could significantly improve radiographic (Stulberg classification) and clinical (Harris hip score) outcomes at skeletal maturity compared to femoral varus osteotomy alone.

## REFERENCES

1. Yavuz U, Demir B, Yildirim T, et al. Salter innominate osteotomy in the treatment of late presentation Perthes disease. *Hip Int* 2014;24:39-43.
2. Mosow N, Vettorazzi E, Breyer S, et al. Outcome after combined pelvic and femoral osteotomies in patients with Legg-Calvé-Perthes disease. *J Bone Joint Surg Am* 2017;99:207-13.
3. Aydin BK, Sofu H, Konya MN, et al. Clinical and radiographic outcomes after femoral varus derotation osteotomy for Legg-Calvé-Perthes disease at 25 years follow-up: what are the determinants of outcome in the long term?. *Hip Int* 2016;26:301-6.
4. Salter RB. Innominate osteotomy in the treatment of congenital dislocation and subluxation of the hip. *J Bone Joint Surg Br* 1961; 43:518-39.
5. Javid M, Wedge JH. Radiographic results of combined Salter innominate and femoral osteotomy in Legg-Calve-Perthes disease in older children. *J Child Orthop* 2009;3:229-34.
6. Crutcher JP, Staheli LT. Combined osteotomy as a salvage procedure for severe Legg-Calve-Perthes disease. *J Pediatr Orthop* 1992;12:151-6.
7. Herring JA. The treatment of Legg-Calve-Perthes disease. A critical review of the literature. *J Bone Joint Surg Am* 1994;76:448-58.
8. Herring JA, Kim HT, Browne R. Legg-Calve-Perthes disease Part II: prospective multicenter study of the effect of treatment on outcome. *J Bone Joint Surg Am* 2004;86:2121-34.
9. Westhoff B, Zilkens C, Reith A, et al. Correlation of functional outcome and X-ray findings after Perthes disease. *Int Orthop* 2011;35:1833-7.

10. Noam S, Leonel C, Yossi S, et al. The long-term outcome after varus derotational osteotomy for Legg-Calve-Perthes disease. *J Bone Joint Surg Am* 2016;98:1277-85.
11. Herring JA, Neustadt JB, Williams JJ, et al. The lateral pillar classification of Legg-Calve-Perthes disease. *J Pediatr Orthop* 1992;12:143-50.
12. Catterall A. The natural history of Perthes' disease. *J Bone Joint Surg Br* 1971;53:37-53.
13. Sarassa CA, Herrera AM, Carvajal J, et al. Early clinical and radiological outcomes after double osteotomy in patients with late presentation Legg-Calve-Perthes disease. *J Child Orthop* 2008;2:425-9.
14. Terjesen T, Wiig O, Svenningsen S. Varus femoral osteotomy improves sphericity of the femoral head in older children with severe form of Legg-Calve-Perthes disease. *Clin Orthop Relat Res* 2012;470:2394-401.
15. Saran N, Varghese R, Mulpuri K. Do femoral or salter innominate osteotomies improve femoral head sphericity in Legg-Calve-Perthes disease? A Meta-analysis. *Clin Orthop Relat Res* 2012; 470:2383-93.
16. Eamsobhana P, Kaewpornawan K. Combined osteotomy in patients with severe Legg-Calve-Perthes disease. *J Med Assoc Thai* 2012; 95Suppl10:S128-34.