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Functional Outcomes of Varus Osteotomy with Locking Compression Plate Fixation in Legg-Calve-Perthes Disease

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Purpose: Patients with Legg-Calve-Perthes disease are treated to preserve the roundness of the femoral head. Surgical treatment includes the proximal femur or acetabulum operations, however, remains controversial. Herein, we investigated the clinical findings and outcomes of varus osteotomy with locking compression plate fixation.

Methods: We reviewed 19 children (20 hips) with Legg-Calve-Perthes disease who underwent varus osteotomy with locking compression plate fixation at our hospital. The time to re-ossification, Stulberg classification, and Harris hip score were recorded preoperatively and at the final follow-up.

Results: We included 16 boys and two girls with unilateral hip involvement and one girl with bilateral hip disease. The mean age at the time of surgery was 7.9 years. Based on the Catterall classification, one, 10, and nine patients were classified as grades II, III, and IV, respectively. All patients were followed for 33 months. The mean time to re-ossification was 167 days. At final follow-up, based on the Stulberg classification, seven, nine, and four patients were categorized as class II, III, and IV, respectively. Based on the Harris hip score, 21.1%, 47.7%, and 31.6% of patients showed excellent, good, and fair functional outcomes, respectively. The Harris hip scores at the final follow-up were significantly improved compared to preoperative values. Following adjustment for sex and disease severity, age at disease onset and time of surgery were associated with Harris hip scores.

Conclusions: Varus osteotomy with locking compression plate fixation yields good results and significantly improves functional outcomes, although patient age affects the outcomes.

Keywords: Legg-Calve-Perthes disease, femoral varus osteotomy, outcomes, Harris hip score

Legg-Calve-Perthes disease is an idiopathic avascular necrosis of the femoral head, observed in children aged 4–9 years and is more commonly observed in boys [1]. The goal of treatment is to maintain the roundness of the femoral head in the acetabular socket to prevent head deformity and secondary osteoarthritis of the hip joint [2]. This reduces the patient's range of motion, with consequent difficulty in walking, sitting, and performing activities of daily living. Non-surgical management includes spica cast immobilization, bed rest, traction, and non-weight walking [3]. Surgical approaches aimed at femoral head containment include femoral varus or valgus osteotomy and pelvic osteotomies, such as innominate (Salter) pelvic osteotomy, lateral shelf osteotomy, and triple osteotomy. Femoral varus osteotomy and salter innominate osteotomy are

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conventional surgical treatments; comparison between these approaches did not show significant differences with regards to radiographic outcomes; a recent study showed that combined osteotomy is the most effective procedure in severe cases [4]. Few studies have compared femoral varus osteotomy with conservative treatment [5-8]. They found that the femoral procedure was superior to brace treatment for late-onset disease [9].

There are various fixations for femoral varus osteotomy, such as locking plates, blade plates, and external fixators. In our cases, locking plates were applied because of the advantage of the fixed-angle device, fewer hardware complications, loss of fixation, and implant-related fractures compared with blade plates [10], avoiding pin tract infection, hip contracture, nonunion, and refracture that occurred in external fixation [11]. Regarding the Harris hip scores, the literature in 2022 mentioned Legg-Calve-Perthes disease outcomes, but no correlation between the Harris hip scores and type of fixation was reported [12].

In this study, we investigated the clinical findings and outcomes of varus osteotomy with locking compression plate fixation performed for Legg-Calve-Perthes disease and the factors associated with Harris hip scores.

MATERIALS AND METHODS

In this descriptive, retrospective study, we analyzed the medical records and radiographic data of 19 children (20 hips) who underwent surgical management for Legg-Calve-Perthes disease between 2013 and 2020. All patients underwent varus osteotomy with locking compression plate fixation. The inclusion criteria were age < 8 years with hip disease categorized as > grade II or age > 8 years with disease category ≥ grade II (Catterall classification), and lateral pillar classification of B/C during the fragmentation stage. Patients with prior hip surgery were excluded from this study.

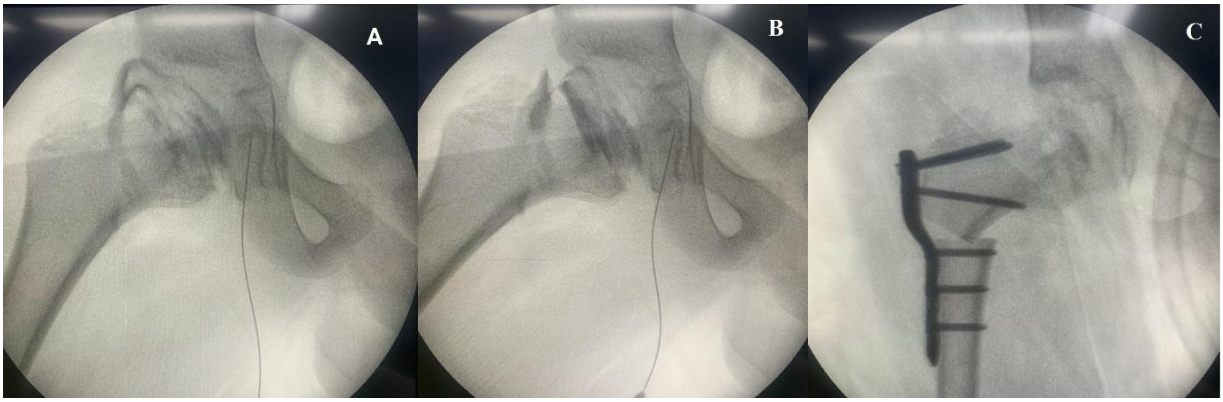

Fig. 1 (A) Arthrogram showing lateral subluxation findings of Legg-Calve-Perthes disease of the right hip in a 7-year-old boy. **(B)** AP radiograph obtained at 30° of hip abduction showing adequate femoral head containment and disappeared lateral subluxate. **(C)** Image showing femoral varus osteotomy using a locking compression plate.
AP: anteroposterior

Regarding the operative technique, the varus angle was selected for fixation following adductor tenotomy and arthrography. We performed osteotomy below the level of the lesser trochanter via the lateral approach, an open wedge was created, and a specific angle-locking plate with three proximal and distal locking screws (Pediatric hip locking plate, B. L. Hua Co.,Ltd) was used for internal fixation (Figure 1. A-C). The surgical goal was femoral head containment within the acetabulum with nearly 100% coverage and greater trochanter position. Subsequently, the patient was transitioned to protected weight-bearing until healing of the osteotomy site was confirmed.

Radiographic parameters, including the Catterall and lateral pillar classification, neck-shaft angle, and leg-length discrepancy were evaluated preoperatively. Changes in the neck-shaft angle, postoperative neck-shaft angle, leg-length discrepancy, Stulberg classification, functional outcomes, and time to re-ossification were evaluated after healing, as described by Waldenstrom. Harris hip scores for pain, function, absence of deformity, and range of motion were reviewed preoperatively and at the final follow-up, information from parents was obtained by interviews, and examination by orthopedic surgeons was also performed. Scores were interpreted as follows: a total score < 70, 70–80, 80–90, and 90–100 represented poor, fair, good, and excellent outcomes, respectively [13]. Data were analyzed by two orthopedic surgeons, and inter-rater reliability was confirmed using the Kappa statistic.

All statistical analyses were performed using STATA version 11 (Stata Corp., College Station, TX, USA), and statistical significance was set at $P < 0.05$. Fisher's exact test was used to assess independence between two dichotomous variables, and an independent *t*-test was used for parametric variables. We used crude odds ratios (OR), adjusted odds ratios (adjusted OR), and 95% confidence intervals to determine factors associated with functional scores based on the literature reviewed (e.g., sex and severity according to Catterall classification) to determine which factors affect patient outcomes [14].

RESULTS

The study included 16 boys and two girls with unilateral disease and one girl with bilateral hip disease. The mean patient age at the time of surgery was 7.9 years (range: 6–11 years). Based on the Catterall classification of Legg-Calve-Perthes disease, one, 10, and nine patients were categorized as Catterall grades II, III, and IV, respectively, and 11 and nine patients were categorized as lateral pillar grades B and C, respectively. All patients underwent follow-up for 2.8 years (range: 1.2–5.4 years) after varus osteotomy with locking compression plate fixation. The mean postoperative time to re-ossification was 5.5 months. The mean limb length discrepancy was 1.0 cm (range: 0.3–2.5 cm) at the time of the last follow-up. Based on the Stulberg classification, seven (35%), nine (45%), and four (20%) patients were categorized as classes II, III, and IV, respectively. Based on Harris hip scores, 21.1%, 47.7%, and 31.6% of the patients showed excellent, good, and fair functional outcomes,

Table 1 Patient demographic data and radiographic parameters with regards functional outcome.

	Good and Excellent outcome (n=14)	**Fair outcome (n=6)**	**p-value**
Age at onset (Mean (SD))	7.07 (0.28)	9.33 (0.55)	0.0009
Age at surgery (Mean (SD))	7.28 (0.26)	9.33 (0.55)	0.0014
Catterall classification			0.740
2 (frequency (percent))	1 (7.14)	0 (0.00)	
3	6 (42.86)	4 (66.67)	
4	7 (50.00)	2 (33.33)	
Lateral pillar			> 0.9999
B (frequency (percent))	8 (57.14)	3 (50.00)	
C	6 (42.86)	3 (50.00)	
Stulberg classification			0.03
2 (frequency (percent))	7 (50.00)	0 (0.00)	
3	6 (42.86)	3 (50.00)	
4	1 (7.14)	3 (50.00)	
Preoperative NS angle (degrees) (Mean (SD))	142.92 (1.79)	140.66 (3.31)	0.5245
Postoperative NS angle (degrees) (Mean (SD))	130.42 (2.06)	129.66 (1.72)	0.8243
NS angle change (degrees) (Mean (SD))	12.50 (1.66)	11.00 (3.41)	0.6610
Preoperative LLD (mm) (Mean (SD))	4.64 (0.95)	6.16 (1.62)	0.4075
Time to reossification (months) (Mean (SD))	4.00 (0.93)	6.14 (1.05)	0.2328

SD, Standard deviation; NS angle, Neck-shaft angle; LLD, Leg length discrepancy

Table 2 Factors that affected Harris hip functional scores.

Factors	Odds ratio	Adjust for sex and severity		p-value
		Adjusted odds	95% CI	
Age at disease onset	0.26	0.27	0.001-0.91	0.044
Age at surgery	0.25	0.04	0.002-0.77	0.033
NS angle change	1.01	0.95	0.705-1.29	0.765

CI, Confidence interval; NS, Neck-shaft

respectively. The Harris hip scores recorded at the final follow-up were significantly improved compared with the preoperative values; the preoperative scores were 78. The Kappa statistic for inter-rater reliability was 0.80, indicating substantial agreement.

Table 1 shows a significant difference in age at disease onset and age at the time of surgery ($p < 0.01$) between patients with excellent/good and fair Harris hip scores. Comparison of the preoperative and postoperative neck-shaft angles, preoperative leg-length discrepancy, and time to re-ossification did not show statistically significant differences between functional outcomes. Postoperative leg-length discrepancy was significantly associated with hip kinematics and function; therefore, this variable was not included in the analysis [15].

After adjustment for sex and disease severity, factors that affected the Harris hip score included age at disease onset (OR, 0.26 [0.10–0.78]; adjusted OR, 0.27 [0.001-0.91]; $p > 0.05$) and age at the time of surgery (OR, 0.25 [0.10–0.79]; adjusted OR, 0.04 [0.002-0.77]; $p > 0.05$). The postoperative neck-shaft angle change did not differ between the outcomes ($p > 0.05$) (Table 2).

DISCUSSION

The goal of the surgical management of Legg-Calve-Perthes disease is femoral head containment within the acetabulum during remodeling and ossification, improved sphericity of the femoral head, resolution of clinical symptoms, and improved functional outcomes. Femoral varus osteotomy and salter innominate osteotomy are conventional surgical approaches used in such cases. Femoral varus osteotomy can improve femoral head coverage and sphericity, and does not cause postoperative joint pressure or articular rigidity [1,16,17]. However, weakness of the abductor

Fig. 2 (A-B) Radiographs of bilateral hips in a 7-year-old boy with Catterall grade III Legg-Calve-Perthes disease of the left hip. **(C)** Radiographs of locking compression plate fixations. **(D-E)** Images showing type 3 Stulberg classification; the patient had excellent functional outcomes 2 years postoperatively.

Fig. 3 (A-B) Radiographs of bilateral hips in an 8-year-old boy with Catterall grade III Legg-Calve-Perthes disease of the right hip. **(C)** Radiographs of locking compression plate fixations. **(D-E)** Images showing type 3 Stulberg classification; the patient had good functional outcomes 6 years postoperatively.

mechanism and limb shortening, which are not associated with residual shortening, are disadvantages of this operation [18].

Considering the many advantages of femoral varus osteotomy, this method was selected as the first-line surgical approach for Legg-Calve-Perthes disease. We observed good-to-excellent functional outcomes of up to 68.4% in our study population comprising 19 children (20 hips). Figure 2 (A-E) shows a patient whose functional score improved to excellent (93 points) and Figure 3 (A-E) shows a patient with good outcomes with a postoperative functional score of 81. Similarly, our study showed that Harris hip scores at the final postoperative follow-up were significantly improved compared to the preoperative values. A previous study recommended intertrochanteric varus femoral osteotomy as an acceptable method for managing patients with Legg-Calve-Perthes disease. This operation was associated with reduced pain (assessed using the visual analog scale), limp, and increased range of motion [19]. Similarly, an article on early proximal femoral varus osteotomy shortened the fragmentation phase [20] and the benefits of femoral varus osteotomy during the fragmentation stage were mentioned [21].

With regards to factors that affected function, based on the Harris hip scores, we observed that following adjustments for sex and disease severity, the patients' age at disease onset and at the time of surgery were statistically significant. A meta-analysis reported operative treatment by age [6,7,22]; moreover, a study also reported that disease severity was a statistically significant factor [13]. An agreement study performed in 2008 reported that femoral head involvement ≥ 50% served as the strongest predictor of radiological outcomes, followed by age at the time of diagnosis and disease severity based on the lateral pillar classification [23,24].

With regards to radiographic parameters, such as changes in the neck-shaft angle and preoperative leg-length discrepancy, we observed a disassociation between these parameters and functional outcomes. In this study, the neck-shaft angle in the excellent and good outcome groups was 12.5°, consistent with previous studies which recommend a 10–15° varus correction to achieve a Stulberg radiographic outcome [25].

The strengths of this study are as follows: (a) all patients belonged to the same age group; (b) all patients were treated by the same surgeon; (c) all patients underwent the same surgical procedure; and (d) the same clinical and radiographic rating systems were used for evaluation in all patients.

The limitations of this study are as follows: (a) this is a case series without a comparison group and (b) this was a single-center study.

CONCLUSIONS

Varus osteotomy with locking compression plate fixation is a safe procedure that significantly improves functional outcomes in patients with Legg-Calve-Perthes disease; however, patient age has been shown to significantly affect functional outcomes.

CONFLICTS OF INTEREST

The authors report no conflicts of interest, financial or otherwise, with regards to the materials or methods used or the findings described in this study.

ETHICAL CONSIDERATIONS

This study was approved by the Research Ethics Committee of our institution.

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