Acta Orthop. Belg., 2014, **80**, 56-62

ORIGINAL STUDY

Salter pelvic osteotomy in the treatment of Legg-Calve-Perthes disease : The medium term results

Mehmet Bulut, Abdullah Demirtş, Bekir Yavuz Uçar, İbrahim Azboy, Celil Alemdar, Lokman Karakurt

From Dicle University Medical Faculty, Diyarbakir and Firat University Medical Faculty, Elazig, Turkey

In this study, clinical and radiological results were evaluated in patients with Legg-Calve-Perthes disease treated with Salter pelvic osteotomy.

Between 2004 and 2008, 16 patients underwent a Salter osteotomy as treatment for Legg-Calve-Perthes disease (15 male, 1 female ; 10 right hip, 6 left hip). The mean age at the time of surgery was 8.1 ± 1.4 (range : 6 to 10) years. Surgical indications were : age between 6-10 years at the onset of the disease ; Herring classification type B, B/C, or C ; and at least one risk sign. 6-8 year old patients were classified as group I and 9-10 year olds were classified as group II. We investigated the effects of age and Herring classification on radiological outcomes.

The final radiographic evaluation according to the Stulberg classification showed nine hips (56.25%) classified as good (Stulberg I/II), five (31.25%) as fair (Stulberg III) ; and two (12.5%) as poor (Stulberg IV). In group I, 7 patients (70%) had good results, while only 2 (33.3%) in group II. The results in group I were statistically better than group II ($p < 0.05$). Based on the Herring lateral pillar type, of the 12 patients classified as B or B/C, at final follow-up, 8 (66.6%) had a good outcome (Stulberg I/II), whereas in the four patients classified as type C, only one (25%) had a good outcome.

The Salter pelvic osteotomy is an effective method of surgical treatment for Legg-Cave-Perthes in patients between 6-8 years of age.

Key words : Legg-Calve-Perthes disease, Salter osteotomy, treatment outcome.

INTRODUCTION

Legg-Calve-Perthes (LCP), or idiopathic, avascular necrosis of the femoral head in children, is a disease associated with ischemia, necrosis, and repair of the proximal femoral epiphysis due to a localized or systemic reason, which usually results in sequelae. Although its etiology has not been clarified, the common belief is that it is a multifactorial disease in which genetic and environmental factors play a role. Lateral column involvement, the extent of involvement of the epiphysis, femoral head lateralization (subluxation), age of onset, dis-

■ Mehmet Bulut, MD, Assistant Professor.
■ Abdullah Demirtaş, MD, Assistant Professor.
■ Bekir Yavuz Uçar, MD, Assistant Professor.
■ Ibrahim Azboy, MD, Assistant Professor.
■ Celil Alemdar, MD, Assistant Professor.
Department of Orthopaedics and Traumatology, Dicle University Medical Faculty, Diyarbakİr, Turkey.
■ Lokman KARAKURT , MD, Professor.
Department of Orthopaedics and Traumatology, Firat University Medical Faculty, Elazig, Turkey.
Correspondence : Mehmet Bulut, Department of Orthopedics and Traumatology, Dicle University Medical Faculty, 21218, Diyarbakır, Turkey
E-mail : bulmeh@yahoo.com

No benefits or funds were received in support of this study.

ease stage, and treatment modality have been reported as the most important factors affecting the prognosis (*5,8,13,19*).

The aim of treatment is to obtain a spherical hip joint and to prevent or minimize the risk of degenerative joint disease that may develop at a young age. In his 1966 study, Salter reported the concept of biological plasticity (*22*). According to this theory, if the femoral head is held in the acetabulum during the process of repair, it is predicted that a normal or near-normal femoral head will form. In light of this information, containment therapy has become important in the treatment of Perthes. Containment therapies have been discussed in two parts : surgical containment treatments (pelvic, femoral and combined osteotomies) and non-surgical containment treatments (abduction traction, orthoses). In recent years, arthrodiastasis, which aims to reduce the load to the femoral head, and biological treatment methods, which stimulate new bone formation and reduce bone resorption, have been proposed (*2,16,17,21,24*).

In this study, we evaluated the clinical and radiological results in patients with Legg-Calve-Perthes (LCP) ,who received containment therapy with a Salter pelvic osteotomy.

PATIENTS AND METHODS

The sixteen patients (15 male, 1 female) who have been treated with Salter pelvic osteotomy in our clinic for the diagnosis of LCP between 2004 and 2008 were retrospectively analyzed. All patients had unilateral disease (10 patients (62.5%) had involvement of the right hip, and six had involvement of the left hip). The mean age at time of surgery was 8.1 ± 1.4 years (range 6-10 years). Indications for surgery were : 6-10 years of age at the onset of the disease ; Herring lateral column classification of B, B/C, or C, and at least one radiographic or clinical risk factor (*11*). Clinical risk factors included adduction contracture and decreased range of motion. Radiographic risk factors included subluxation of the femoral head, horizontal position of the epiphyseal line, calcification lateral to the epiphysis, diffuse metaphyseal changes, and Gage sign. Patients had not received any previous regular treatment. Preoperatively, the range of motion was evaluated, and radiographs in both anterior-posterior and frog position were taken. In order to increase the range of motion, the patients were referred to physical therapy and rehabilitation before surgery. Approval of the local ethics committee within our hospital was obtained prior to the start of the study.

Operative technique

A classic Salter osteotomy was performed in the supine position using a bikini incision. The autograft harvested from the iliac bone was placed in the osteotomy line and was fixed with two or three thick Kischner wires. In all cases, the iliopsoas muscle was lengthened at the musculotendinous junction. A pelvipedal spica cast was applied for four weeks after surgery. Rehabilitation was started after the end of the fourth week, and full load was applied at the end of the tenth week.

Pelvic radiographs in both the anterior-posterior and frog position were taken early in the postoperative period, at three, six and twelve months postoperatively, and once a year thereafter. Preoperative and postoperative clinical evaluation was done according to the Harris Hip Score (HHS) (*10*).

In the preoperative radiographic evaluation, Herring's (*11*) lateral column classification and Waldenström's staging were used. In addition, the central edge (CE) angle was measured before and after surgery. The most recent follow-up radiographies were evaluated according to the Stulberg classification (*23*). The impact of the extent of the lateral column involvement on the results was evaluated according to the Stulberg classification. To assess the impact of the age of onset of the disease on the results, patients were divided into two groups. Group I consisted of patients with an age of onset between 6-8 years, and Group II consisted of those who were 9-10 years old at the onset of the disease.

For the statistical analyses, the t-test and Wilcoxon test were used for dependent samples, and the Mann-Whitney U-test and the chi-square tests were used for independent samples. Significance level was set at $p < 0.05$.

RESULTS

The mean follow-up period was 50.9 ± 15.3 months (range 35-84 months). Prior to surgery, containment was complete in two hips, whereas subluxation was present in 14 hips. During the final examination, containment was complete in 11 hips, and subluxation was present in the other 5 hips. Preoperatively, 6 patients had a normal walking

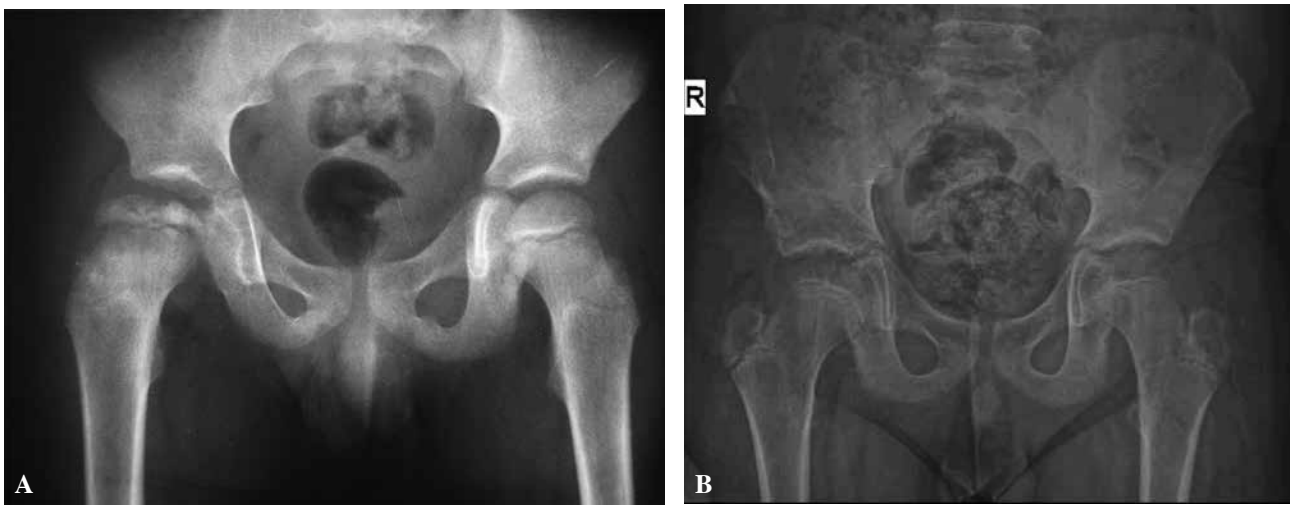

Fig. 1. — A : 7-year-old male, right hip, Herring type B, Preoperative AP radiograph. B : Postoperative radiograph at 5 years. Stulberg I, HHS : 100.

pattern while 10 patients had a limp ; during the final examination, 12 patients had a normal walking pattern and 4 patients had a limp. Preoperatively, 10 patients had an average length discrepancy of 1.2 cm, whereas during the final examination, 6 patients had an average length discrepancy of 0.7 cm. According to Herring's lateral column classification, preoperatively there were 4 (25%) type B, 8 (50%) type B/C, and 4 (25%) type C hips. According to Waldenström's staging, 3 hips (18.7%) had avascular necrosis, 11 hips were (68.8%) in the fragmentation stage, and 2 hips (12.5%) were in the reossification stage.

The mean preoperative CE angle was 14.9 ± 4.9˚, the early postoperative angle was 32.9 ± 4.9˚, and at the last control it was found to be 30.3 ± 3.8˚. The difference between the preoperative and the final examination was statistically significant ($p < 0.01$). There was a statistically significant difference between the preoperative mean HHS (71.06 ± 6.99) and the final examination mean HHS (92.56 ± 5.12) ($p < 0.01$).

Regarding the impact of the Herring's lateral column involvement on the radiological results, the four hips which were type B preoperatively became respectively Stulberg classification type I (n = 2), type II (n = 1), and type III (n = 1) at final control (Fig. 1A, B). The eight hips that were Herring B/C preoperatively became respectively Stulberg classification type I (n = 1), type II (n = 4), type III (n = 2), and type IV (n = 1) at final examination (Fig. 3A, C). The four hips that were Herring C preoperatively became respectively Stulberg classification type II (n = 1), type III (n = 2), and type IV (n = 1) at final examination (Fig. 2A-C) (Table I).

Between Group I and Group II, which were formed to evaluate the effect of age of onset on the results, there was no statistically significant differ-

Table I. — The effects of lateral column involvement on radiological results.

Herring	Number of hips	Stulberg-1	Stulberg-II	Stulberg-III	Stulberg-IV
B	4	2	1	1	-
B/C	8	1	4	2	1
C	4	-	1	2	1
Total	16	3 (18.75%)	6 (37.5%)	5 (31.25%)	2 (12.5%)

Fig. 2. — A : 7-year-old male, right hip, Herring typ C, Preoperative AP. B : Postoperative radiograph at 6 months. C : Postoperative AP radiograph at 7 years. Stulberg type II.

ence in terms of lateral column involvement. There were ten patients in Group I with a mean age of 7.2 years. Group II was comprised of six patients with a mean age of 9.6 years. According to the Stulberg classification, in Group I, good results were achieved in seven (70%) patients, whereas only two (33.3%) patients in Group II had good results. The results in Group I were significantly better ($p < 0.01$) than Group II (Table II).

No complications such as nonunion, loss of graft reduction, infection, and nerve palsies were encountered.

Table II. — Stulberg classification at the last examination according to age groups

Stulberg	Group I (6-8 years)	Group II (9-10 years)
I	3	0
II	4	2
III	2	3
IV	1	1
P value < 0.05		

DISCUSSION

The basic principle of the treatment of LCP is to reduce the load on the femoral head by providing coverage of the femoral head during the biological plastic phase. For this purpose, many conservative and surgical treatment modalities have been attempted (*3,4,6,15,18*). However, it has been report-

Fig. 3. — A : 6-year-old male, left hip, Herring type B/C, Preoperative AP radiograph. B : Postoperative radiograph at 3 months. C : Postoperative AP view at 6 years. Stulberg type III. The roundness of the femoral head is lost ; it has taken an oval shape and is compatible with the acetabulum.

ed that surgical containment should be preferred to conservative treatment methods because of the roundness of the femoral head ; the deterioration of the roundness of the femoral head increases the risk of the development of early degenerative osteoarthritis (*12,20,23,28*). For these reasons, the surgical containment of the femoral head has recently been used more frequently in the treatment of LCP patients between the ages of 6-10 years (*1,9,25*).

Surgical options include pelvic osteotomies, proximal femoral osteotomies, combined osteotomies, which are a combination of both techniques, and arthrodiastasis. Among these options, the most frequently used method is the Salter pelvic osteotomy. The Salter osteotomy has the advantages of providing a better containment of the femoral head anteriorly and laterally, causing a prolongation of the limb by about 1cm, and correcting the Trendelenburg gait, as well easy implant removal and no risk of pathologic fracture (*25*). In addition, this method has been reported to accelerate the revascularization of the epiphysis, which in turn triggers a biological effect and shortens the active phase of the disease (*7*). However, in patients with advanced age and severe deformity, a Salter osteotomy alone may not be sufficient for the rotation of the acetabulum and the containment of the femoral head; therefore, additional procedures and different methods may be required (*27*). Furthermore, the extra pressure applied on the femoral head by the Salter osteotomy is a disadvantage of this technique (*29*).

In their study comparing three different methods of treatment of LCP (physiotherapy, orthotics and femoral osteotomy), Wiig *et al* achieved the least

successful results below and above 6 years of age in the group with the Scottish Rite orthosis (*28*). For patients less than six years of age, there was no difference between the results of physiotherapy and femoral osteotomy, while above six years of age, femoral osteotomy was found to be superior to physiotherapy. In a study on the Atlanta Scottish Rite orthosis, Martinez *et al* recommended that weight-bearing braces should not be used in the treatment of LCP (*18*).

In their prospective study of the hips of 345 6-12 year old patients with five different treatment methods, Herring *et al.* found no differences among the three groups : without treatment, treatment with brace, and treated with range of motion ((ROM) exercises (*12*). Furthermore, the authors reported that they obtained better results after surgery in patients with an age of onset above 8 years and with lateral column B and B/C, whereas the results were often poor in cases with type C. The best results were achieved with Salter osteotomy in the group with an age of onset of 6-8 years (69% Stulberg type I and II).

Ishida *et al.* treated 37 cases with Salter osteotomy (*14*). After an average follow-up of 115 months, the hips were evaluated according to the Stulberg classification. 11 hips were evaluated as Type I, 5 hips as Type II, 13 hips as Type III, and 6 hips as Type IV. They reported the radiological results (according to Stulberg) of those treated at less than 7 years of age to be better, but that age did not have any effect on the clinical outcomes.

In the final follow-up of 40 patients treated by triple pelvic osteotomy, Wenger *et al.* obtained 42% good results (Stulberg I and II), 47% intermediate results (Stulberg III), and 11% poor results (Stulberg IV, V) (*24*). The results were better in Herring B hips compared to Herring C hips ; patients treated younger than 8 years fared better than the older patients.

In our study of 16 cases, we found that the radiological results (according to Stulberg) of Group I were significantly better compared to that of Group II ($p < 0.05$). As far as clinical outcomes, the mean HHS in Group I was 95 while 85 in Group II ; this difference was not statistically significant. The rate of good radiological results (Stulberg Type I and II) in Group I was 70% ; this rate was 33.3% in Group II.

Of the 12 hips, which were Herring Type B and B/C according to the lateral column involvement preoperatively, 8 (66.6%) were evaluated as good according to the final Stulberg classification. This rate was only 25% (1 hips) in Herring Type C. We believe that either the addition of a proximal femoral osteotomy or a triple osteotomy would be a more appropriate treatment option in cases of severe deformity and in patients over 8 years old, as a Salter osteotomy alone does not provide sufficient rotation and containment.

Further studies are needed with a greater number of subjects, longer follow-up, and standard groups. However, as stated by Ishiada *et al*, this is rather difficult due to the difficulty of pre-operative standardization, the age at the time of the treatment, the radiographic findings with regard to the femoral head at the end of the disease process, the numerous factors that affect the results, and the creation of control groups (*14*).

These studies and the present data suggest that, in the treatment of patients with Perthes, which has a risk of poor prognosis especially in patients in the 6-8 year old age range, Salter pelvic osteotomy is a convenient and effective method of treatment given current knowledge. However, the understanding of the etiology of LCP and the development of treatment options directed toward this etiology will bring more successful options for treatment.

Acknowledgement

We are grateful to Dicle University DUBAP for their sponsorship about English editing of this manuscript.

REFERENCES

1 **Aksoy MC, Cankus MC, Alanay A, Yazici M, Caglar O, Alpaslan AM**. Radiological outcome of proximal femoral varus osteotomy for the treatment of lateral pillar group-C Legg-Calve-Perthes disease. *J Pediatr Orthop B* 2005 ; 14 : 88-91.

2. **Amer AR, Khanfour AA.** Arthrodiastasis for late onset Perthes disease using a simple frame and limited soft tissue release: early results. *Acta Orthop Belg* 2011 ; 77 : 472-479.

3. **Atlihan D, Subasi M, Yildirim M.** Proximal femoral varus osteotomy for Perthes disease. *Joint Diseases and Related Surgery* 1999 ; 10 : 155-159.
4. **Aydın H, Turhan AU, Yıldız M.** Results of conservative treatment in Perthes' disease. *Joint Diseases and Related Surgery* 1993 ; 4 : 55-58.
5. **Bahmanyar S, Montgomery SM, Weiss RJ, Ekbom A.** Maternal smoking during pregnancy, other prenatal and perinatal factors, and the risk of Legg-Calve-Perthes disease. *Pediatrics* 2008 ; 122 : 459-464.
6. **Baki ME, Baki D, Aydın H, Kerimoğlu S, Baki C.** Radiological evaluation of combined valgus extension osteotomy and tectoplasty for the treatment of Herring group C Perthes patients. *Joint Diseases and Related Surgery* 2011 ; 22 : 64-68.
7. **Canale ST, D'Anca AF, Cotler JM *et al.*** Innominate osteotomy in Legg-Calve-Perthes disease. *J Bone Joint Surg [Am]* 1972 ; 54 : 25-40.
8. **Catterall A**. Legg-Calve-Perthes syndrome. *Clin Orthop Relat Res* 1981 ; 158 : 41-52.
9. **Dogan A, Zorer G, Ozer UE**. Treatment of acetabular dysplasia by triple pelvic osteotomy and its short-term results. *Acta Orthop Traumatol Turc.* 2007 ; 41 : 355-366.
10. **Harris WH.** My first 50 years of orthopeadic surgery. *J Arthroplasty* 2001 ; 8 (Suppl. 1) : 16 : 2-7
11. **Herring JA, Kim HT, Browne R.** Legg-Calve-Perthes disease. Part I: classification of radiographs with use of the modified lateral pillar and Stulberg classifications. *J Bone Joint Surg Am* 2004 ; 86 : 2103-2120
12. **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 : 2121-2134.
13. **Herring JA.** Legg-Calve-Perthes Disease at 100 : A Review of Evidence-based Treatment. *J Pediatr Orthop. Supplement* 2011 ; 31 : 137-140.
14. **Ishida A, Kuwajima SS, Filho JL, Milani C.** Salter Innominate Osteotomy in the Treatment of Severe Legg-Calve-Perthes Disease. Clinical and Radiographic Results in 32 Patients (37 Hips) at Skeletal Maturity. *J Pediatr Orthop* 2004 ; 24 : 257-264
15. **Kerimoglu S, Cıtlak A, Baki C, Aydın H**. The long-term results of brace treatment in Perthes disease. *Joint Diseases and Related Surgery.* 2012 ; 23 : 25-29.
16. **Kocaoglu M, Kilicoglu OI, Goksan SB, Cakmak M.** Ilizarov fixator for treatment of Legg-Calve-Perthes disease. *J Pediatr Orthop B* 1999 ; 8 : 276-281.
17. **Little DG, McDonald M, Sharpe IT, Peat R, Williams P, McEvoy T.** Zoledronic acid improves femoral head sphericity in a rat model of perthes disease. *J Orthop Res* 2005 ; 23 : 862-868.
18. **Martinez AG, Weinstein SL, Dietz FR.** The weight-bearing abduction brace for the treatment of Legg-Calve-Perthes disease. *J Bone Joint Surg Am* 1992 ; 74 : 12-21.
19. **Miyamoto Y, Matsuda T, Kitoh H, Haga N, Ohashi H, Nishimura G, Ikegawa SA.** Recurrent mutation in type II collagen gene causes Legg-Calve-Perthes disease in a Japanese family. *Hum Genet* 2007 ; 121 : 625-629.
20. **Mose K.** Methods of measuring in Legg-Calve´-Perthes disease with special regard to the prognosis. *Clin Orthop Relat Res* 1980 ; 150 : 103-109.
21. **Saini R, Goyal T, Dhillon MS, Gill SS, Sudesh P, Mootha A.** Outcome of varus derotation closed wedge osteotomy in Perthes disease. *Acta Orthop Belg* 2009 ; 75 : 334-339.
22. **Salter RB.** Role of innominate osteotomy in the treatment of congenital dislocation and subluxation of the hip in the older child. *J Bone Joint Surg Am* 1966 ; 48 : 1413-1439.
23. **Stulberg SD, Cooperman DR, Wallensten R.** The natural history of Legg-Calve-Perthes disease. *J Bone Joint Surg Am* 1981 ; 63 : 1095-1108.
24. **Sudesh P, Bali K, Mootha AK, Dhillon MS, Saini R.** Arthrodiastasis and surgical containment in severe late-onset Perthes disease : An analysis of 14 patients. *Acta Orthop Belg* 2010 ; 76 : 329-334.
25. **Thompson GH.** Salter Osteotomy in Legg-Calve-Perthes Disease. *J Pediatr Orthop* 2011 ; 31 : 192-197.
26. **Wenger DR, Pring ME, Hosalkar HS *et al.*** Advanced containment methods for Perthes disease : results of triple pelvic osteotomy. *J Pediatr Orthop* 2010 ; 30 : 749-757.
27. **Wenger DR, Pandya NK** Advanced Containment Methods for the Treatment of Perthes Disease : Salter Plus Varus Osteotomy and Triple Pelvic Osteotomy. *J Pediatr Orthop Supplement* 2011 ; 31 : 198-205.
28. **Wiig O, Terjesen T, Svenningsen S.** Prognostic factors and outcome of treatment in Perthes disease: a prospective study of 368 patients with five-year follow-up. *J Bone Joint Surg Br* 2008 ; 90 : 1364-1371.
29. **Vukasinovic Z, Spasovski D, Vucetic C, Cobeljic G, Zivkovic Z, Matanovic D.** Triple pelvic osteotomy in the treatment of Legg-Calve-Perthes disease. *International Orthopaedics (SICOT)* 2009 ; 33 : 1377-1383.