

# Labral Support Shelf Arthroplasty for the Early Stages of Severe Legg-Calvé-Perthes Disease

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## Abstract

The best treatment for Legg-Calvé-Perthes disease remains unknown, and various methods of treatment have been shown to yield conflicting results. Treatment with a labral support shelf arthroplasty is ideal when an increased arc of the acetabulum is needed to contain an enlarged femoral head, when extension of the lateral border of the acetabulum is needed to prevent hinge subluxation, and when a larger surface area is needed for remodeling.

Twenty patients with unilateral Catterall classes III and IV and lateral pillar groups B and C disease in the necrotic or fragmentation stage were treated with a shelf arthroplasty. Eleven hips demonstrated hinge subluxation. Success was defined as achievement of a round or oval femoral head, and failure was defined as a flat femoral head. Clinical examination evaluated the presence of pain, limp, and range of motion. Eighteen of the 20 hips (90%) had a successful result. Hinge subluxation was eliminated in all 11 hips. All 18 patients with a successful result had no pain, no limp, and a functional range of motion. The 2 hips considered a failure were in the oldest patients.

Treatment with a labral support shelf arthroplasty fostered femoral head sphericity and prevented incongruence in hips otherwise at risk for poor results. Ninety percent of hips had a round or oval femoral head with no pain, no limp, and a functional range of motion.

This study was conducted at the Alfred I. duPont Hospital for Children, Wilmington, Delaware.

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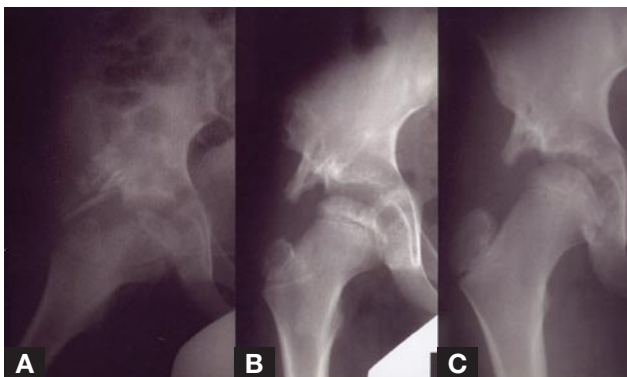
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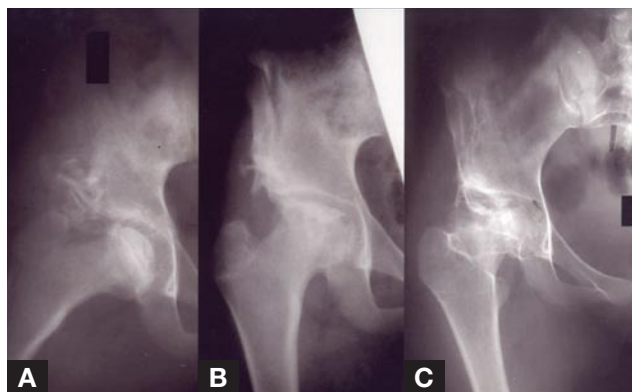
The initial goals of treatment in Legg-Calvé-Perthes disease are to prevent deformity and maintain function. This can be done by a variety of non-operative and operative methods with varying results. Recent studies have suggested that similar results can be expected from these modalities and procedures.<sup>1</sup> Unfortunately, patients present at various stages of the condition, thus limiting the surgeon's ability to achieve a satisfactory result in the presence of a pre-existing deformity. In one study of 480 hips with Legg-Calvé-Perthes disease, only 200 of the hips presented with a predeformed epiphysis.<sup>2</sup> Once the femoral head becomes deformed, the chances of obtaining a spherical congruent joint diminish.<sup>3</sup>

The shelf operation was originally described by Gill<sup>4</sup> in 1935 for acetabular dysplasia secondary to congenital hip dislocation. Its use in Legg-Calvé-Perthes disease, with good results, was briefly reported by van der Heyden and van Tongerlo<sup>5</sup> in 1981. In 1991, Kruse and colleagues<sup>6</sup> reported the long-term follow-up with good results of 20 hips in 19 patients who were treated in the late stages of the disease. Willett and colleagues<sup>7</sup> reported that shelf arthroplasty was a good treatment option for children older than 8 years with severe Legg-Calvé-Perthes disease, a point supported recently by Daly and colleagues.<sup>8</sup>

The role of this procedure for hips in the early stages of Legg-Calvé-Perthes disease, however, is not known. We strongly believe that the prevention of deformity is of the utmost importance in the early treatment of this condition.



**Figure 1.** (A) Postoperative image of the right hip of a 9-year-old girl with Legg-Calvé-Perthes disease. (B) At age 10 years, anteroposterior view shows that the arc of the acetabulum has been increased and the femoral head is covered. (C) There has been excellent remodeling of the femoral head, with improved sphericity and persistence of the shelf graft, at age 14 years.



**Figure 2.** (A) Postoperative image of the right hip of a 12-year-old girl with Legg-Calvé-Perthes disease. (B) At age 13 years there is flattening of the femoral head. (C) Severe femoral head deformity (failure) was noted at the age of 18 years.



**Figure 3.** (A) Postoperative image of the right hip of a 12-year-old boy with Legg-Calvé-Perthes disease. (B) At age 13 years there is flattening and irregularity of the femoral head. (C) Early osteoarthritic signs were evident at age 19 years.

Theoretically, the addition of a bone shelf to the lateral acetabular edge will increase the arc of the acetabulum to “contain” the coxa magna, thus providing a larger surface area for remodeling and preventing deformation from hinge subluxation. It was therefore the purpose of the present study to define the role of the labral support shelf arthroplasty in a consecutive series of patients with early-stage severe Legg-Calvé-Perthes disease.

## MATERIAL AND METHODS

All consecutive patients with Legg-Calvé-Perthes disease treated by the labral support shelf arthroplasty (shelf arthroplasty) who had no other operative procedures performed on the hip were included in this study. A minimum of 2 years of clinical and radiographic follow-up was required. The hips in late stages (reossification and remodeling) of Waldenstrom were excluded, as were patients with bilateral involvement. Twenty patients met these criteria. Demographic data consisted of gender, involved side, age at onset of the disease, age at the time of surgery, and length of follow-up (Table).

Preoperative radiographs were classified with the classifications of Waldenstrom,<sup>9</sup> Catterall,<sup>10</sup> and Herring and colleagues.<sup>11</sup> The presence of hinge subluxation was verified if there was disruption of Shenton’s line, widening of medial joint space, and lateral displacement of the femoral head.<sup>12</sup> The indications for the operation were the presence of hinge subluxation and/or lateral pillar B or C and Catterall class III or IV involvement. All radiographs were reviewed concurrently in chronological order by all of the authors until a consensus was reached for each patient.

Radiographs were evaluated by the center-edge angle to estimate improvement in the coverage of the femoral head. The classification of Stulberg and colleagues<sup>13</sup> was simplified to describe the resultant femoral head shape, as some of the patients had not yet reached skeletal maturity. The shape was considered either round or oval (classes

I, II, and III) or flat (classes IV and V). A round or oval head shape was defined as a success, and a flat shape was defined as a failure. At the time of the most recent follow-up, patients were examined and questioned concerning pain, range of motion, and limp.

According to the Waldenstrom classification,<sup>9</sup> 9 hips were in the necrosis stage and 11 hips were in the fragmentation stage. In the classification of Catterall,<sup>10</sup> 10 hips (50%) were class III and 10 hips (50%) were class IV. In the lateral pillar classification, 11 hips were group B (55%), and 9 hips (45%) were group C. Hinge subluxation<sup>12</sup> was present in 11 hips.<sup>11</sup> The average preoperative center-edge angle was 20.7° (range, 7° to 40°).

Intraoperative arthrograms were done prior to the shelf operation to look for hinge abduction. Then, an adductor tenotomy was done to increase the arc of abduction of the affected hip and to reduce hinge subluxation when present. All hips had the shelf arthroplasty performed through a standard anterolateral approach. Copious amounts of autogenous iliac crest bone graft and morselized allograft were used at the discretion of the attending surgeon. All patients wore a single leg hip spica cast for 6 weeks and were non-weight-bearing on the operated extremity. After this time, the patients were fitted with an abduction brace to be worn at night for an additional 6 weeks. Gentle physical therapy to increase range of motion of the hip was started, and progressive weight bearing was allowed when maturation of the shelf graft was noted on radiographs.

## RESULTS

Twenty patients (4 girls and 16 boys) with unilateral hip involvement (10 right and 10 left) met the inclusion criteria. The average age at the time of the shelf arthroplasty was 9 years (range, 6–12 years). The average age at last follow-up was 14 years (range, 10–21 years), and the average length of follow-up was 5 years (range, 3–14 years).

The average center-edge angle was significantly improved at the last follow-up at 44° (range, 18° to 65°)

**Table. Patient Data**

No.	Age at Shelf Arthroplasty	Age at Follow-up	Catterall Class	Waldenstrom Stage	Herring Classification	Preop CEA (°)	Follow-up CEA (°)	Modif/Stulberg	Evolution
1	5.9	10.9	4	Necrosis	C	21	50	2	O-O
2	6.6	10.3	3	Fragmentation	B	16	43	3	H-O
3	6.8	11.1	3	Necrosis	B	31	46	2	H-O
4	7	11.4	3	Necrosis	B	20	47	3	H-O
5	7.2	11.0	4	Fragmentation	C	20	18	3	O-O
6 <sup>a</sup>	7.2	10.8	4	Fragmentation	B	16	41	3	O-O
7	7.4	21.0	3	Fragmentation	C	10	44	3	O-O
8	8.2	11.4	3	Necrosis	B	20	32	2	O-O
9	8.3	13.5	4	Fragmentation	C	10	39	3	H-O
10	8.4	15.3	4	Fragmentation	C	7	45	2	H-O
11	8.5	14.9	4	Necrosis	B	17	52	2	H-O
12 <sup>a</sup>	8.5	12.9	4	Fragmentation	C	7	28	3	H-O
13	9.5	12.5	3	Fragmentation	B	16	50	2	O-O
14	9.5	12.9	3	Necrosis	B	32	38	3	O-O
15	9.5	12.5	3	Necrosis	C	23	65	3	H-O
16	10	17.3	3	Fragmentation	C	25	32	3	H-O
17 <sup>a</sup>	11	16.6	4	Fragmentation	B	40	65	2	O-O
18	11.3	16.3	3	Fragmentation	B	10	38	2	H-O
19 <sup>a</sup>	12.1	18.1	4	Necrosis	C	37	50	4	H-F
20	12.1	19.0	4	Necrosis	B	35	65	4	O-F
<b>Mean</b>	<b>8.7 years</b>	<b>14 years</b>				<b>20.7°</b>	<b>44°</b>		

<sup>a</sup>Female patients.

Abbreviations: H = hinge subluxation; O = round or oval femoral head (Stulberg et al. classes I-III); CEA=center-edge angle; F=flat femoral head.

( $P<.05$ ). The femoral head shape at follow-up was round or oval in 18 hips (successes) and flat in 2 hips (failures). At the time of the most recent follow-up, all of the patients with a successful result had a pain-free hip, no limp, and functional range of motion (Figure 1). Abductor weakness generally took 4 months to resolve. All scars were cosmetically acceptable.

Among the 11 hips with hinge subluxation, 1 case resulted in a flat femoral head and failure, and 1 of the 9 hips without hinge subluxation evolved to a flat femoral head and failure. Both hips with a flat femoral head had been in the necrosis stage at the time of operation, and both were in older patients (both 12 years old) (Figures 2, 3). Both of these patients had a limited abduction and internal rotation at their last visit.

## DISCUSSION

The goal in the treatment of Legg-Calvé-Perthes disease is to prevent deformity and incongruity of the hip and to delay the onset of degenerative arthritis in later adult life.<sup>14</sup> The most important prognostic factors in determining the outcome in Legg-Calvé-Perthes disease are the degree of necrosis of the capital femoral epiphysis, age at onset of symptoms, and deformity of the femoral head.<sup>15</sup> The surgeon has no control over the age at onset or severity of the disease. Hips with severe Legg-Calvé-Perthes disease that have lateral displacement, flattening, or collapse of the femoral head often have incongruity, which may result in an abnormal hip at maturity. Later age at onset of disease is thought to have a worse prognosis, because time available for remodeling of the deformed femoral head is decreased. During the late necrotic stage and

the entire fragmentation stage, the capital femoral epiphysis has the potential to deform. At this time, axial loading, compression, widening of the femoral head, and lateral extrusion lead to hinge subluxation and progressive incongruity. This point in time is crucial, as the surgeon potentially has the opportunity to influence the outcome.

Many treatment methods have been proposed to minimize femoral head deformity. Containment of the femoral head within the acetabulum is currently the preferred method, especially in the necrosis and fragmentation stages.<sup>1,16-23</sup> It is somewhat controversial to reduce the subluxation and contain the femoral head during the active phase of the disease.<sup>24</sup> Regardless of the method selected, it is imperative to make an early diagnosis and initiate treatment before marked deformity occurs.

The concept of shelf arthroplasty involves the reduction of the femoral head into the acetabulum to eliminate hinge subluxation and improve femoral head coverage.<sup>4,6,7</sup> Its use as a reconstructive procedure for Legg-Calvé-Perthes disease was reported with good results by Kruse and colleagues.<sup>6</sup> However, the role of shelf arthroplasty for the pre-deformed femoral head is not well known. The literature shows that younger age at onset of symptoms in Legg-Calvé-Perthes disease is usually associated with a good outcome, because younger patients have a greater growth potential of the femoral head and acetabulum, which may allow for more remodeling.<sup>7</sup>

In the current study, most of the patients were older than 7 years, and most of them had a satisfactory result, which is better than would be expected from the natural history.<sup>25</sup> Willett and colleagues<sup>7</sup> also reported that shelf arthroplasty

performed in children older than 8 years had better results than found in non-treated patients, but they did not mention the severity of disease or Waldenstrom stage at the time of operation. Of the 7 patients over age 9 years, 5 had a satisfactory result, which bodes well for the use of shelf arthroplasty in this select group of patients. In comparison with several reports of containment treatment,<sup>2,22,23,26</sup> operative or nonoperative, our results are more favorable.

Hinge subluxation, which comes from the lateral extrusion, flattening, and enlargement of the femoral head deformity in the early stage of Legg-Calvé-Perthes disease, may produce incongruity and a lack of functional range of motion.<sup>12</sup> The damage done to the femoral head from hinge subluxation can be devastating if left untreated. Therefore, it is paramount that this deforming force be eliminated. It is in this role that the shelf arthroplasty may play its greatest part.<sup>6,8</sup> In the current study, the presence of the hinge subluxation did not affect the outcome of shelf arthroplasty, as 10 of the 11 hips thus affected had a successful result, with the hinge subluxation eliminated. We believe that operative containment with the addition of a lateral shelf prevents and corrects hinge subluxation.

The extent of necrosis of the femoral epiphysis is another important prognostic factor in Legg-Calvé-Perthes disease, one over which the treating surgeon has no control. In the present series, all hips had either Catterall class III or IV and either lateral pillar group B or C involvement, and all but 2 hips had successful results. Age of patient at onset of disease is said to be an important prognostic factor. All of our patients younger than age 12 years at the time of surgery had a successful result. Daly and colleagues<sup>8</sup> reported a high chance of a poor result in girls presenting after the age of 11 years.

We realize that the number of patients in the present series is small, and that some of the patients were not followed to skeletal maturity. We want to emphasize, however, that the labral support shelf arthroplasty is a viable option in the treatment of early-stage severe Legg-Calvé-Perthes disease. Traditionally, shelf arthroplasty has been thought of as a reconstructive procedure, a notion perpetuated by its role in the treatment of developmental hip dysplasia. We need to look at this subject with a different perspective, as the 2 conditions and the goals of treatment are different. In developmental dysplasia of the hip, the shelf arthroplasty serves to augment a deficient acetabulum. The role of the labral support shelf arthroplasty in Legg-Calvé-Perthes disease is to increase the volume of the acetabulum to accommodate an enlarged femoral head, provide a greater surface area for remodeling, and prevent incongruity from hinge subluxation.

## AUTHORS' DISCLOSURE STATEMENT

The authors report no actual or potential conflict of interest in relation to this article.

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