Legg-Calvé-Perthes disease treatment by augmentation acetabuloplasty


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KEYWORDS
Legg-Calvé-Perthes disease; Shelf acetabuloplasty

Summary
Introduction: Classical surgical treatments for Legg-Calvé-Perthes (LCP) disease are pelvic or femoral osteotomies, which are not without complications and inconvenience for the patient. An effective, relatively undamaging surgical alternative would improve this disease treatment. Hypothesis: Augmentation acetabuloplasty using shelf acetabuloplasty is a recognized treatment for LCP disease, but its results have never been assessed in view of Herring's lateral pillar classification, the current reference in determining the prognosis of this disease. Assessment of its efficacy based on this system is therefore needed.

Material and methods: Over 15 years, 21 patients underwent shelf acetabuloplasty. Included in the study were children with a progressively subluxating femoral head and classified minimum grade B in the lateral pillar classification. The last follow-up had to be at least 12 months after surgery and include a clinical examination as well as an AP pelvic X-ray.

Results: The mean follow-up was 4 years and 3 months. Only two complications occurred, one of which required surgical revision. Shelf acetabuloplasty was considered effective (contained and Stulberg 1 or 2) in 13 cases and ineffective (lysed or Stulberg 3, 4, or 5) in eight cases.

Discussion: The lateral pillar classification demonstrated its high value in LCP disease in correlation with symptom onset. This series shows that at the medium term, shelf acetabuloplasty is as effective as pelvic or femoral osteotomies for children of any age and any level of disease severity, with fewer complications and less inconvenience for the patient.

Level of evidence: Level IV. Therapeutic retrospective study

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Introduction

The objective of treatment for Legg-Calvé-Perthes (LCP) is to prevent joint incongruity so as to delay osteoarthritic degeneration, the most dreaded complication of this disease [1,2,3,4]. Over the past few years, the indications for
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The most current treatments, proximal femoral varus osteotomies or pelvic osteotomies, have long demonstrated their efficacy for recentering the femoral head within the acetabulum, the principle of LCP treatment. Nevertheless, these are interventions that are not without complications and inconvenience for the patient, with a long postoperative immobilization and the need for a second surgery to remove the material. Moreover, consensus has not been reached on the indications for these treatments.

Given these observations, it is logical to seek treatment that minimizes the risks of complication while reducing the side effects, which could be provided by augmentation acetabuloplasty using the shelf acetabuloplasty technique. We therefore propose herein the follow-up of a preliminary study conducted in 2003 [5] on the medium-term analysis of the results of an original shelf acetabuloplasty technique for treating LCP disease.

Material and methods

This was a retrospective study on 26 shelf acetabuloplasties performed between 1992 and 2007 in 26 children (22 boys and four girls) who had LCP disease. Patient age at the onset of signs and at surgery were noted as were pre- and postoperative presence of pain and limping as well as hip mobility limitations. On the radiographs, the progressive phase, according to the Waldenström classification [6] modified by Jonsäter [7] and severity according to Catterall [8] and Herring et al. [9] were studied. Subluxation was measured by the proximal femoral metaphysis—acetabulum roof horizontal distance. Offset was measured by the horizontal distance separating the most lateral part of the femoral epiphysis and the vertical tangent of the upper external edge of the acetabulum. The Wiberg angle [10] (or center edge [CE] angle) was quantified. Since this angle cannot have an absolute value because coxa plana makes it difficult to measure, it was only used to assess the progression of the femoral head coverage. At the end of reconstruction, the sphericity of the femoral head was assessed using the Stulberg classification [4] reviewed by Herring et al. [11].

The inclusion criteria for this study were children between 0 and 15 years of age with uni- or bilateral LCP, at least at the beginning of the fragmentation stage according to the Waldenström classification, who presented a femoral head that was misaligning, with proximal femoral epiphyseal offset. The hip had to be classified a minimum grade II or Catterall grade B according to Herring’s lateral pillar classification. The follow-up had to be a minimum of 12 months and include an AP pelvic X-ray and hip mobility measurements. A total of 21 patients were included, 19 boys and two girls. The operative indication was retained for an increase in subluxation and proximal femoral epiphyseal offset (minimum Catterall grade II or Herring grade B) whatever the other parameters were. The intervention is based on Staheli and Deanna’s slotted acetabular augmentation [12,13]. The difference can be summarized to respecting the continuity of the reflected head of the rectus femoris, individualized and dissociated distally 1 to 2 cm from the direct tendon. The bone graft harvested from the external side of the coxal bone is then introduced in a groove over the acetabulum as near as possible to the capsular attachment so that the acetabular roof can be prolonged and maintained by this reflected tendon, itself covered with a layer of corticocancellous bone stabilized using bone wax. After checking that the femoral head is properly covered by the graft and that there is no impingement in abduction and flexion, a shelf of cancellous bone is put in place. Postoperative immobilization is provided in most cases by a resin pantaloon cast, which allows full weightbearing.

It is widely accepted that the results judged to be good are those corresponding to Stulberg grades 1 and 2. Stulberg grade 3 hips are considered mediocre results, and the two other grades are deemed poor results [14].

In this series, shelf acetabuloplasty was considered effective when, a priori, it modified the natural history of the disease: Herring B, B/C, or C off-centering hips whose prognosis was poor. To be considered effective, the graft had to be integrated, with good radiographic density during the entire reconstruction period to ensure proper mechanical function. Finally, at the last follow-up, these hips had to be classified Stulberg 1 or 2. The shelf acetabuloplasties that were considered ineffective or were not integrated showed osteolysis and were not mechanically solicited (a posteriori proof of an erroneous therapeutic indication) or corresponded to Stulberg 3, 4, or 5 hips, making it clear that the treatment could not modify the natural history of the disease.

Results

The mean age at diagnosis was 7 years and 2 months (Table 1). The mean time between the beginning of symptoms and surgery was 10.4 months. At the time of diagnosis, all patients presented limping, which was painful in 17 (81%). The mean limitation of hip abduction, compared to the healthy side, was 32° and the internal rotation limitation was 26°.

Radiologically, 19 hips were at the fragmentation stage and two at the end of the fragmentation/beginning of reconstruction stage. A mean off-centering of 11.8 mm (range, 5–20 mm) and 8.2 mm (range, 4–15 mm) femoral head external offset was found. The mean preoperative Wiberg angle was measured at 26.2°. The extent of epiphyseal involvement found, according to Catterall, was three grade II, seven grade III, and 11 grade IV hips, and according to Herring’s lateral pillar classification there were 13 grade B, four grade B/C, and four grade C hips. The other classifications, including Salter and Thompson’s [15], were not studied.

None of the patients was operated on both hips. The mean hospital stay was 40.5 hours (range, 36–72 hours).

Postoperative immobilization was provided by a resin pantaloon cast in 18 cases and a spica cast in two cases. In one case, no means of immobilization was fabricated. Immediate complete weightbearing was authorized in 19 cases out of 21.
<table>
<thead>
<tr>
<th>Patient</th>
<th>Gender</th>
<th>Age at beginning</th>
<th>Operative age</th>
<th>Preoperative mobilities (degrees)</th>
<th>Radiological stage</th>
<th>Catterall</th>
<th>Herring</th>
<th>Off-centring (mm)</th>
<th>Offset (mm)</th>
<th>Preoperative CE angle (degrees)</th>
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<td>ALA</td>
<td>M</td>
<td>3 y 11 m</td>
<td>4 y 6 m</td>
<td>Abd-30/ir-25</td>
<td>Fragmentation</td>
<td>IV</td>
<td>C</td>
<td>12</td>
<td>5</td>
<td>15</td>
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<td>8 y</td>
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y: years; m: months; NC: not communicated.
## Table 2  Postoperative data.

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<th>Immediate bearing</th>
<th>Complication</th>
<th>Shelf integration (months)*</th>
<th>Last control (months)</th>
<th>Claudication (degrees)</th>
<th>Off-centring (mm)</th>
<th>Offset (mm)</th>
<th>CE angle (degrees)</th>
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<th>Stulberg</th>
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y: years; m: months; NC: not communicated.
Two postoperative complications were reported: scar outflow that spontaneously dried up and a reaction to the bone wax with scar outflow and cyst formation requiring surgical lavage at a later time. At the last follow-up, no other complication was found.

Twenty-one patients were followed with a mean follow-up of 4 years and 3 months (Table 2). From a clinical standpoint, one-third of the patients still complained of limping at the last follow-up (7/21) but with a significant reduction of discomfort compared to the preoperative exam. In four patients, hip pain persisted but less than during the preoperative exam. Hip mobility became complete and symmetrical in four patients. For the remaining 17, the mean abduction limitation compared to the opposite side was 17° and 10.7° for internal rotation. At the last follow-up, no clinical deterioration was observed.

From a radiological standpoint, 18 out of 21 shelves were perfectly contained into the coxal bone, two showed complete lysis, and one never achieved containment. In 18 patients, the graft showed very good radiographic density, with one fractured into two splinters with no consequences on disease progression (Fig. 1).

At the end of the follow-up, the mean misalignment was 10.6 mm (range, 6—17 mm), the femoral head offset was $-2.3$ mm (range, $-16$ to $15$ mm), and the Wiberg angle was a mean $50.43°$ (range, $20°—76°$). The analysis of the femoral head sphericity found two patients out of 21 classified as Stulberg grade 1, 12 grade 2, one grade 3, five grade 4, and one grade 5.

Given these results (Table 3), 13 shelf acetabuloplasties out of 21 could be considered effective, with a good result on hips with a mediocre prognosis, i.e., at least Herring grade B and in the process of becoming off-centered (Fig. 2), and eight shelf acetabuloplasties that could be considered ineffective (Fig. 3). Among these cases, one shelf showed lysis but with an acceptable result, with the hip classified as grade 2. Of the seven other cases, five patients were classified Herring B or B/C and were over 8.5 years of age when symptoms appeared (Fig. 3). The two other patients were less than 6 years old at symptom onset and at surgery, but both were classified Herring grade C. The radiographic analysis showed that in these seven patients, the shelves had globally less coverage than the shelf acetabuloplasties judged to be ineffective. This tends to demonstrate that either a shelf that has little coverage is not effective or that shelf lysis occurs in certain situations and remains to be analyzed.

Therefore, all the patients who had a poor radiological and clinical result presented severe forms of LCP disease (Herring grade C) or late forms (onset of first symptoms after 8.5 years of age). In these children, at the last follow-up, the shelves provided less coverage than in children who had a good result.

### Discussion

A large number of studies have investigated the treatment of LCP disease [16,17], but in the last few years, the indications have tended to change, not only in relation to patient age, but also depending on the severity of the disease.
Figure 1  a: 4-year-old child. LCP disease, Herring grade C off-center; b: at 9 years after surgery. Stulberg grade 1 despite shelf fracture.

Figure 2  a: 8-year-old child. Herring grade B off-center; b: immediate postoperative aspect; c: AP view at 4 years after surgery. Stulberg grade 1; d: lateral aspect.

Figure 3  a: Child aged 9 years and 5 months. Herring grade B/C; b: view 4 years after surgery; c: view 5 years after surgery; Stulberg grade 4 with aspherical congruity.
In 2004, Herring demonstrated that his lateral pillar classification was superior to Catterall’s and Salter’s classifications in terms of intra- and interobserver reliability [11], just as he demonstrated its very high predictive value when it was associated with the age of symptom onset in children over 6 years of age [14]. His study’s conclusions showed that all grade A hips have an excellent prognosis and do not require treatment. Hips classified as grade B or B/C, in children between 6 and 8 years of age at the beginning of the disease (or with bone age less than 6 years), have an overall good prognosis and do not benefit from surgical treatment. However, in children over 8 years of age (or with a bone age greater than 6 years) with grade B or B/C hips, surgical treatment (innominate osteotomy or femoral varus osteotomy) provides significantly better results. Finally, children presenting a grade C hip have a poor prognosis no matter what the child’s age at symptom onset or what treatment is provided. No upper age limit was specified.

Few studies have investigated LCP disease treatment with shelf acetabuloplasty. Initially described by Köenig in 1891 for congenital hip dislocations [18], only much later was LCP disease studied in terms of its effectiveness. In 1981, Van der Heyden and Van Tongerloo [19] reported good results in 25 patients with Catterall grade III or IV hips. Kruse et al. [20] also found good results after a comparative study between 19 operated patients and 17 nonoperated patients, all with severe disease. In operated patients, they reported significant improvement in the sphericity of the femoral head and acetabular cover. In these two studies, there was no lower age limit. In 1992, Willet et al. [21] also found very good results with shelf acetabuloplasty in children older than 8 years when comparing the results of 20 operated and 14 nonoperated children at 22 months of follow-up. They demonstrated that shelf acetabuloplasty is effective treatment for off-centering and prevents the incongruity from worsening. Dimitriou et al. [22] came to the same conclusion after studying 14 patients aged 9 to 12 years. In 1999, Daly et al. [23] studied 26 patients and confirmed the results of Willet et al. With a mean follow-up of 5.9 years, they concluded that shelf acetabuloplasty seemed to be useful in 8- to 11-year-old patients, providing better results than innominate osteotomy or femoral varus osteotomy.

As in our series, Kuwajima et al. [24] performed this procedure with no lower age limit on stiff Catterall grade III and IV hips with worsening off-centering so as to compare the results with the Salter innominate osteotomy. At the last follow-up, they showed that the radiological results were the same for both treatments. Willet and Laville [5] found good results in 13 hips out of 16, with a follow-up period that was too short to allow them to draw solid conclusions. In 2004, Jacobs et al. [25] reported a study on a series of 43 patients. Their results suggest improved prognosis in children presenting severe forms of the disease and with symptom onset at ages over 5 years, with a significant increase in femoral coverage. In 2006, in 20 Herring grade B or C patients, Haddad et al. [26] demonstrated the efficacy of shelf acetabuloplasty at the medium term.

Despite the growing interest in shelf acetabuloplasty in treating LCP disease, none of the studies evaluated its results in relation to the contribution by Herring et al. [11,14]. Our series shows that none of the shelf acetabuloplasties were detrimental to the patients in terms of the Herring criteria. Of the five patients over 6 years at diagnosis and presenting Stulberg stage 3, 4, or 5 hips, all were Herring stage B and over 8.5 years old at the onset of the first symptoms. Shelf acetabuloplasty therefore did not alter the natural history of the disease in these cases. It should be mentioned, however, that in certain poor results, partial lysis of the shelf, sometimes poorly positioned, did not extend the acetabular roof. This may be the cause of the poor result since two other patients aged more than 8 years with Herring grade B or B/C hips evolved more favorably with Stulberg grade 2 hips at the end of growth (Fig. 2).

In 2007, Rosenfeld et al. [27] studied 160 patients under 6 years of age at symptom onset and showed that the prognosis was good for any treatment applied, except for patients between the ages of 4 years and 5 years 11 months who presented a grade B/C or C hip. In our series, two poor results (Stulberg 4) were less than 6 years old at diagnosis and at surgery and both presented Herring grade C hips. Once again, poor shelf positioning could explain some of these poor results. Another Herring grade C patient had satisfactory progression: with disease onset at 3 years and 11 months and operated on 7 months later, at 105 months of follow-up, he presents a Stulberg grade 1 painless hip with normal mobility (Fig. 1). All Herring grade C hips therefore do not necessarily progress unfavorably and deserve to have their treatment discussed.

In view of these results, it seems that shelf acetabuloplasty can be as effective as other surgical treatments at the medium term and that certain poor results can be explained by shelf position but also by the absence of a precise selection of the surgical indications for this disease. Today, the choice between pelvic or femoral osteotomies remains standard. Too many disparities between the different studies make any statistical comparison impossible and the follow-up period has not yet been sufficient to fully assess the results. Only a long-term study with CT or orthographic analysis can stipulate the indications of the different surgical treatments for LCP disease.

Femoral varus osteotomy remains the reference surgical treatment [28–31] but is accused of certain disadvantages or complications such as femur shortening (even though long-term studies do not confirm this hypothesis [32]), excessive varus, ascension of the greater trochanter, osteonecrosis, or nonunion [33,34]. After a study on more than 1000 patients, the SOFCOT 2007 Symposium on total hip arthroplasty in the young subject [35] also demonstrated that during childhood hip disease, indications for conservative surgery, in particular femoral osteotomies, should be thoroughly deliberated. These procedures may lead to femoral deformations severely complicating any future prosthesis implantation and may also be a notable negative factor for long-term prosthesis survival.

Pelvic osteotomies also remain a classic treatment even though the choice among the different procedures is a matter of preference. Some prefer the Chiari osteotomy [36,37], others the Salter innominate osteotomy [38]. A combined osteotomy to realign and enlarge the acetabulum has also been proposed for very severe forms of the disease [39]. None of these techniques has proven superior to the others and all can involve complications. The Salter innominate osteotomy covers as much as it uncovers, alters the pelvic architecture with the risk of dystocia, and becomes deli-
cate to perform after the age of 6 years, when it is replaced by triple pelvic osteotomy. The risk of sciatic neurological involvement is recognized in Chiari osteotomies [40]. These femoral and pelvic surgical techniques have similar results, with, however, a tendency toward better cover with the latter [41]. They all have in common that they provide good femoral head cover with hyalin cartilage, which is not the case with shelf acetabuloplasty, but they can also lead to not insignificant consequences on the future of operated hips. Moreover, they require long postoperative immobilization, no loading, and a second intervention to remove the osteosynthesis material.

In our series, only two patients out of 21 were not allowed weightbearing at the beginning of our experiment. With the shelf maintained by the reflected tendon of the rectus femoris, use of the knee during walking provided a better application of the shelf on the joint capsule. This is why immobilization using a simple pantaloon cast and rapid loading were recommended. Similarly, material ablation was not necessary. Two minor complications were noted but left no sequelae. Finally, since no architectural modification is prompted, in particular at the acetabular growth plate [25], shelf acetabuloplasty does not foster pelvic or femoral deformation, thus clearing the way for future arthroplastic treatment if need be.

Conclusion

Since Herring’s work in 2004, the therapeutic indications for LCP disease have changed and the advantages of surgical treatment in children older than 6 years bone age presenting a hip with progressive subluxation, classified as B or B/C have been underscored. In these children, shelf acetabuloplasty seems to be a valuable alternative to pelvic or femoral osteotomies, although a study on a larger sample of patients over a longer follow-up period would provide more precise indications. Nevertheless, shelf acetabuloplasty treatment seems to be able to modify the natural history of LCP disease at the medium term, while respecting the morphology of the hip and, at worst, only run the risk of being ineffective.

Conflicts of interest statement

None.

References