Original Research Article

Surgical Procedure in Legg-Calvé-Perthes Disease: A Systematic Review

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ABSTRACT

Legg-Calvé-Perthes disease (LCPD) is an adolescent hip disorder characterized by idiopathic osteonecrosis of the femoral epiphysis and believed to be associated with arterial infarction. This illness typically affects youngsters, specifically those between the ages of 4 and 8. This research seeks to investigate the impact of surgical operations on LCPD patients. September 2022 was the month during which we conducted a systematic review study. Google Scholar, NCBI, and Science Direct were used to search for articles. We included six publications with 208 patients in total. Our data indicate that this surgical approach can lower pain levels, increase femoral head coverage, and reduce hip subluxation in LCPD patients.

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BACKGROUND

Since Arthur Thornton Legg, Jacques Calvé, and Georg Perthes first described Legg-Calvé-Perthes disease (LCPD) in 1910, it has never failed to raise issues.[1,2] LCPD is a hip disorder brought on by a temporary interruption of blood flow to the proximal femoral epiphysis, which can be brought on by idiopathic coagulopathy, thrombophilia, trauma, or infection.[3] Pediatric orthopedic surgeons address one of the most prevalent but least understood diseases.[4] Boys are more likely to be affected by this sickness than girls, and it typically strikes kids between the ages of 4 and 8.[3] Between 2 to 21 cases per 100,000 children under the age of 15 have been documented.[5,6]

Smoking, social deprivation, low birth weight, and shorter birth length are only a few risk factors found for LCPD.[6] The goal of LCPD therapy is to maintain the hip range of motion while reducing clinical symptoms (particularly pain) and immobilizing the affected hip. Operative and non-operative techniques of treatment are categories for treatments.[4]

To prevent or delay the onset of osteoarthritis at skeletal maturity, the optimal treatment aim for LCPD is a spherical femoral head with good congruency.[7–9] Unaffected by treatment, the prognosis for patients younger than five years with a good remodeling capacity is excellent. Those older than eight years have a poor prognosis, mainly if left untreated. In addition to the age at diagnosis and operation, the severity of femoral head flattening and the presence of "head at risk" indications influence the final clinical result.[8] Our objectives were to determine the outcomes of surgical procedures on Legg-Calvé-Perthes disease (LCPD).

METHOD

This study employed a qualitative methodology based on a systematic literature review (SLR) approach. These articles were obtained from various sources, including Google Scholar, NCBI, and Science Direct. These search terms are 'Legg-Calvé-Perthes (LCPD)' AND 'Surgery'. Articles must have been published within the last decade, between 2012 and 2022. All scientific publications received from these sources are then archived in the Mendeley program to assist in selecting the most pertinent articles for this research. Full-text articles that match the inclusion criteria will be chosen for further analysis. In addition, articles from studies that passed the screening procedure will be evaluated. Each of the included studies extracted the following data: study, the number of patients, mean age at surgery, mean follow-up months, surgical indication, surgical procedure, and outcome.

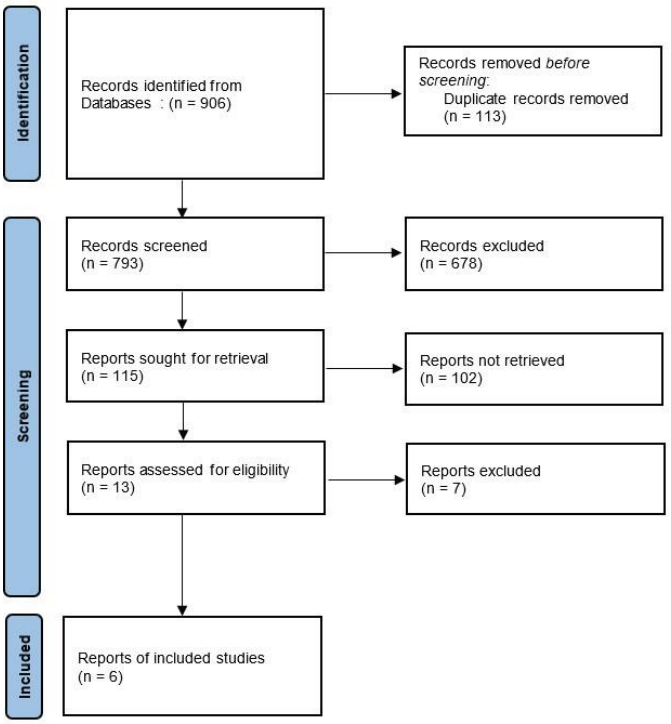

Figure 1. Systematic review flowchart adapted from PRISMA guidelines.

RESULT

Table 1. Results of data analysis

Study	Number of patients			Hip affected		Age at surgery (year)	Mean follow-up (months)	Surgical Indication	Surgical Procedure	Outcome
	Male	Female	Total	Left	Right					
Shore et al., 2012[7]	19	10	29	16	13	17 (range, 9–35)	36	(1) groin discomfort exacerbated by physical activities and hip-flexing positions, such as prolonged sitting; (2) positive anterior impingement sign on physical examination; (3) radiological evidence of hip deformity as a result of healed LCPD.	Surgical Dislocation followed by various proximal femoral and acetabular osteotomies	Improved WOMAC score, reduced pain, increased range of motion and function, and a low failure rate.
Albers et al., 2012[10]	29	24	53	20	33	21 (range, 7–47)	98.4	(1) pain; (2) inadequate hip function (limp, positive anterior and posterior impingement test, impaired abductor strength); (3) decreased ROM; (4) abductor weakness; (5) early degenerative changes.	Surgical Dislocation followed by various proximal femoral and acetabular osteotomies	Pain relief, increased range of motion, enhanced hip abductor strength, and minimal progression of osteoarthritis.
Moghadam et al., 2013[4]	25	4	29	12	20	9 (range, 4–12)	-	(1) patient with Herring lateral pillar calcification of B and B/C border; (2) age of more than 8 years old (3) not responding to conservative treatment.	Varus femoral osteotomy	Relief of pain (according to VAS), improved range of motion, reduced subluxation of the femoral head, reduced limb shortening and reduced limping.

Table 1. Results of data analysis

Li and Xu, 2016[8]	40	11	51	19	32	9.23 (range, 7.92–11.25)	132.35	(1) patient with Herring lateral pillar calcification of B, B/C, and C; (2) patient with Caterall calcification of II or more; (3) age of more than 8 years old.	Lateral shelf acetabuloplasty	Favorable hip clinical function and favorable Stulberg outcomes increase femoral head covering and decrease femoral head subluxation.
Elzohairy, 2016[11]	23	0	23	15	8	7.8 (range, 6–11.5)	36.2	(1) age of more than 6 years old; (2) lateral subluxation; (3) advanced femoral head involvement.	Varus femoral osteotomy	Improved epiphyseal extrusion index, Wiberg's central edge angle, neck–shaft angle, and Larson (Iowa) hip score.
Bhuyan, 2016[9]	19	4	23	13	10	6.6 (range, 4–9)	64.8	(1) Patients with severe illness for whom standard approaches of femoral head confinement are ineffective; (2) patient with Caterall calcification of III and IV; (3) patient with Joseph's staging of IIA, IIB, and IV; (4) patient with Herring lateral pillar calcification of B, B/C, and C.	Varus femoral osteotomy followed by innominate osteotomy	Postoperative clinical results based on Ratliff classification mostly good, postoperative Mose criteria of radiological grading index mostly fair, improved epiphyseal extrusion index, low failure rate.

DISCUSSION

Legg–Calvé–Perthes disease (LCPD) is idiopathic avascular necrosis of the femoral head in children. It is a leading cause of hip osteoarthritis in young adults and frequently demands early hip replacement.[4,8,9] This may also result in irritation of the hip joint and, depending on its degree, distortion of the femoral head.[4] LCPD primarily affects males between the ages of 4 and 8 and has been linked to the Caucasian race. There are considerable differences in incidence rates between countries, within countries, and even within regions. The reported incidence ranges between 0.2 and 21 per 100,000 children younger than 15 years old. [3–6] On both sides, the hip involvement ratio was similar.[4] In each study included in this systematic review, LCPD prevalence was found to be higher in men with the same hip involvement ratio.

Numerous risk factors for developing LCPD have been discovered, including cigarette smoke exposure, obesity, hyperactivity, unknown coagulopathy, and nutritional inadequacies. However, none of these etiologies has been definitively implicated.[6,8] The biological effects of LCPD involve a sequence of events beginning with the eventual revascularization of the femoral head, followed by a change in the femoral head's form, flattening, and possibly dislocation.[3,8]

Conservative care and various surgical procedures are all viable alternatives for treating LCPD. Conservative care demands prolonged excessive degrees of abduction in an orthosis, which further jeopardizes the vascularity of the femoral head capital. When it is desirable, surgical containment techniques are utilized.[9,11] Early therapy aims to avoid head deformation caused by weight-related stresses during remodeling and ossification; hence, containment is the generally recognized treatment principle.[8,11]

Although there is an understanding that patients less than 5 years with a good ability for remodeling have an especially favorable prognosis, regardless of treatment. Those older than 8 years have a typically bad prognosis, especially if untreated.[8] In recent research studies that have been carried out, many surgeries are performed on patients of varying ages, not to mention that operations are performed on much older patients. This can be caused by many factors, for example, delay in diagnosis, economic factors, patient readiness, or other factors.

The age of disease onset, the extent of involvement of the femoral capital epiphysis, radiographic 'head at risk' symptoms, and the presence and extent of epiphyseal extrusion determine the choice to treat LCPD surgically.[9,10] According to Bhuyan et al., among these other factors, extrusion appears to be the most significant predisposing factor for femoral head deformation. If the epiphyseal extrusion index is greater than 20%, it is quite probable that irreversible femoral head deformation will occur. Epiphyseal extrusion is the only factor that can be influenced by confinement treatment. Extrusion always occurs sooner or later in the progression of the disease in older children; consequently, containment measures are implemented as soon as the condition is identified. Due to the unpredictability of extrusion development in young children, they must be regularly monitored, and containment must be provided as soon as extrusion is detected.[9]

Patient complaints are also an important factor to determine surgery. Research by Shore et al. and Albers et al. found that groin pain, poor hip function, decreased range of motion (ROM), abductor weakness, and a positive anterior impingement sign on physical examination were all necessary for surgical intervention.[7] Again, we have to attend to the patient's complaints rather than only focus on the findings of supporting exams.

The present therapy of LCPD is based on an expanding knowledge of its natural history. Containment of the femoral head within the acetabulum, which can be

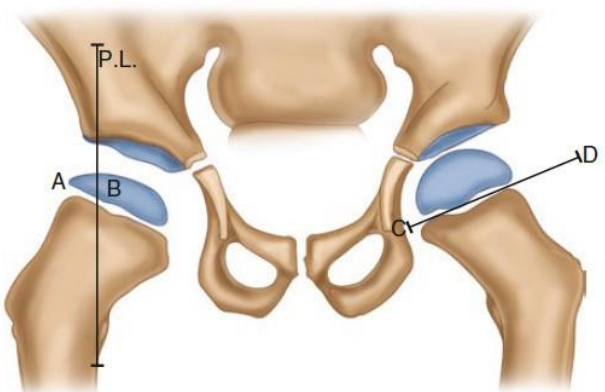

Figure 2. The epiphyseal extrusion index quantifies femoral head subluxation, also known as epiphyseal extrusion. The implicated ossific nucleus lateral to Perkins' line (PL) is measured and divided by the diameter of the contralateral normal femoral head along the epiphyseal plate multiplied by 100.[12]

accomplished nonoperatively or surgically is presently the preferred way of therapy. The femoral head can be reconstructed and remodeled through the combined effects of the "containment" principle and the physiologic flexibility of osteocartilaginous structures in children. It stops the femoral head from shifting laterally, so the bone doesn't flatten out when it heals.[9]

Since the original report by Axer in 1965, femoral varus osteotomy has become one of the most prevalent surgical procedures for LCPD.[3,4,11] This approach aims to position the femoral head deep inside the acetabulum and concurrently address flexion and rotational deformities. This technique requires an adequate range of motion, hip congruency, and the capacity to contain the femoral head in abduction. In the early stages of fragmentation, when favorable biological and biomechanical outcomes might be predicted, this procedure is recommended.[3] Seventy to ninety percent of femoral varus osteotomy advocates reported favorable outcomes.[4,11] In most cases, femoral varus osteotomy enables realignment and identification of the optimal hip position, while restoring joint congruity and reducing femoroacetabular impingement.[3]

In independent studies, Moghadam et al. and Elzohairy utilized the Varus femoral osteotomy technique.[4,11] When it comes to femoral valgus osteotomy, on the other hand, the main objectives are to improve symptoms and range of motion, and to decrease hinged abduction during the remodeling process. Adduction results in greater congruency than abduction in severely deformed femoral heads treated with femoral valgus osteotomy. During the fragmentation phase, this approach kept the malformed femoral head within the acetabulum so that it could be molded to fit snugly within the acetabulum. In addition, the valgus osteotomy is beneficial for relieving hinged abduction once skeletal maturity has been attained.[11] In conclusion, both studies found that proximal femoral varus osteotomy benefits children aged 6 to 10 without femoral head deformity or flatness, particularly those with adequate containment in abduction. Technical blunders, poor patient selection, and lengthy wait times account for the vast majority of treatment failures.[4,11]

When redirection osteotomy is deemed insufficient to provide optimal covering of an extruded femoral head, lateral shelf acetabuloplasty may be attempted for severe LCPD. In extreme circumstances, a laterally displaced and enlarged femoral head will inhibit proper hip mobility. Previous research has demonstrated that shelf acetabuloplasty is a safe and effective treatment for aspherical congruency or incongruency with hinge abduction. When an arthrography reveals femoral head deformity with unstable movement and hinge abduction, but stability in adduction and flexion, valgus and extension osteotomy can be an efficient technique for unloading the malformed epiphyseal segment and relieving femoroacetabular impingement. The efficacy of femoral valgus extension osteotomy depends on weight-bearing neutralization of the more congruent and spherical anteromedial portion of the femoral head. This sagittal and rotational correction may enhance gait and hip motion, reduce pain, and improve the form of the femoral head.[3] In the study by Li and Xu, lateral shelf acetabuloplasty was able to increase the femoral head's containment within the acetabulum, a vital factor during growth. The acetabular covering of the femoral head and the CE angle increased; the increase in the acetabular covering of the femoral head and the CE angle may result in enhanced hip containment for femoral head remodeling. After the trial, the ratio of medial joint space (a1/a2) decreased, as did the average Sharp angle. Shelf acetabuloplasty could improve femoral head subluxation based on the statistical data described previously.[8]

Ganz and colleagues studied the architecture of the medial circumflex artery and described a technique for surgical dislocation of the hip (SHD) that did not compromise the blood supply to the femoral head in the early 2000s.[13,14] In the study conducted by Shore et al. and Albers et al., SHDs were performed, followed by a variety of proximal femoral and acetabular osteotomies.[7,10] The SHD permits a comprehensive dynamic evaluation of hip motion to identify impingement regions (anterior, lateral, anterolateral, or global) and the optimal joint congruency position. It also permits the correction of all femoral abnormalities with a low risk of femoral head avascular necrosis. It is possible to do a relative femoral neck lengthening with trochanteric advancement to correct extra-articular impingement caused by a high-riding greater trochanter and a short, wide neck. When osteochondroplasty of the head-neck junction and femoral neck lengthening are insufficient to alleviate femoroacetabular impingement, a femoral osteotomy may be performed. This technique also allows for the repair of labral and chondrolabral lesions and acetabular retroversion via acetabular rim osteochondroplasty and labral refixation. Due to the intricacy of the technique, the disadvantages of the SHD

include the depth of the surgical dissection, the increased trochanteric osteotomy that requires meticulous postoperative rehabilitation, including the use of crutches for 6 to 8 weeks, and the related learning curve.[14] In both studies SHD led to an increase in WOMAC scores, a decrease in pain, an increase in range of motion and function, enhanced hip abductor strength, and a minor advancement of osteoarthritis in postoperative findings.[7,10]

In more severe cases of LCPD, the triple innominate osteotomy is another option for achieving containment. According to several research, older age and severe femoral head involvement are risk factors for disappointing results. It is predicted that triple innominate osteotomy will prevent the leg length disparity associated with femoral varus osteotomy. Any pelvic osteotomy may be coupled with a proximal femoral osteotomy, particularly when the femoral head cannot be confined by a pelvic or proximal femoral varus osteotomy alone. Patients with older age at clinical onset, malformed femoral heads, or in whom osteotomy alone cannot offer appropriate containment typically have these combined treatments.[14] Bhuyan reported this combined procedure in which he conducted a one-stage combination osteotomy consisting of the varus femoral osteotomy and the innominate osteotomy.[9] While there are no drawbacks, such as limb shortening or abductor mechanism weakness, the procedure does improve the anterolateral covering of the femoral head. Because it moves the acetabulum inward, it reduces the amount of abductor effort required to maintain the hip and increases the lever arm of the abductors. Iatrogenic hinge abduction can occur after osteotomy if the LCPD is too severe to allow for sufficient acetabular rotation to cover the femoral head.[9,11]

Osteotomy offers the advantage of shortening the course of the disease and bypassing the fragmentation phase to reach the regeneration phase. The hypervascularization effect of subtrochanteric osteotomy increases retinal revascularization by increasing blood flow to the femoral head and acetabulum. This surgical procedure achieves a concentric reduction of the femoral head, which applies mechanical pressure that stimulates biological stimulation that ultimately leads to increased acetabular size. Patients younger than 6 years old in this study fared well. Patients with severe LCPD who also have lateral extrusion, deformity, and femoral head collapse have a poor long-term prognosis but now have another surgical option.[9]

Patients with LCPD who have surgery have not been studied to determine what factors might affect their recovery. Findings suggest that the amount of growth left and the possibility of femoral head remodeling make age a relevant prognostic factor for LCPD, especially in the younger age range.[9] Studies found that women with LCPD fared worse than men in terms of survival, the severity of the disease, and the risk of complications.[4,9] Due to their more severe delayed skeletal development, boys with LCPD have a stronger tendency for remodeling.[9]

Regardless of the surgical approach, surgical treatment for LCPD is considered more effective than non-surgical treatment. In each center, the application of operating procedures is contingent on the operator's skill and routines.

CONCLUSION

The treatment for LCPD continues to evolve and improve. Surgical treatment is anticipated to relieve pain and enhance the position of the bone regardless of the surgical method. The results demonstrated that surgery can alleviate discomfort, increase femoral head covering, and decrease hip subluxation.

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