

Comparison of Conservative and Surgical Treatment in Patients with Legg-Calve-Perthes Disease

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Abstract

Original Research Article

Objectives: The overall main purpose of this study is to add some knowledge on the treatment of LCPD, with a main focus on the comparison between conservative and surgical treatments of Legg-Calve-Perthes Disease (LCPD). And a brief overview of the complications of these treatments. **Methods:** A retrospective cohort method was used in this study. A total number of 53 patients were registered with LCPD, at the first affiliated hospital of Xinjiang Medical University. Out of these 53 patients, 39 patients were included in this study, rest of 14 patients couldn't be included due to missed data or loss of contact. For the comparison of results, a modified form of the Harris Hip Score (HHS) was used for the clinical assessment of hip function. Radiographs were also used for the evaluation. The radiological assessment was made by the use of CE and CCD angles. The main classification system, which was used for the evaluation, staging, and prognosis of hip function, was Stulberg's classification. Statistical analysis was done by using the SPSS 23.0 version. A simple t-test was used for data analysis. **Results:** The clinical results supported our hypothesis that surgical treatment is a better choice of treatment than conservative treatment in patients with LCPD. However, the statistical data from radiographic assessment showed no significant difference between conservative and surgical treatment in patients with LCPD. The statistical data showed that both conservative and surgical treatment had significant p-values (<0.05) when compared results at the final follow-up check with that before starting treatment. So conservative treatment can be used as an alternative to surgical treatment in patients with Legg-Calve-Perthes Disease. **Conclusion:** From the statistical analysis of data, we concluded that there is no significant difference between outcomes of conservative and surgical treatment in patients with Legg-Calve-Perthes Disease (LCPD). So conservative treatment can be suggested for Legg-Calve-Perthes Disease (LCPD). But still, further studies are required to shed light on the treatment of LCPD. Because clinically the quality of life of conservatively treated patients is still lower than that with surgically treated patients, though radiologically there is no significant difference between these two modes of treatments. **Keywords:** Legg-Calvé-Perthes Disease, Ischemic necrosis, coagulation, risk factors, CE angle (Central Edge Angle), CCD angle (Caput-Collum-Diaphyseal Angle/Femoral neck-shaft angle), Osteotomy.

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INTRODUCTION

Legg-Calvé-Perthes Disease (LCPD), shortly known as Perthes Disease, is an avascular necrosis of the femoral head. It typically occurs in children of age between 3 to 10 years [1-4]. The prevalence of this disease in boys is 5 times more common than that in girls. LCPD annual incidence ranges from 0.45/100,000 to 21/100,000 in black African children (Purry 1982) from South Africa and Liverpool children (Hall *et al.*, 1893) respectively. And the white children are more likely to develop LCPD than the black children. It is usually diagnosed in children younger than 12 years of age. But,

the peak onset of the disease is from 5 to 8 years of age [5-7]. Most of the time the disease is unilateral. The previous reports have suggested in 10 to 20 % of cases it's bilateral [8]. The incidence rate of this disease in the UK shows an interesting pattern, a low incidence rate in London, and an increased rate of this disease in northern areas like Scotland. But the reason for this pattern is unknown. However, some researches show that it's more prevalent in socioeconomically deprived communities, though the reason for this is still unknown. Some studies suggest it is due to tobacco exposure.

The etiology and prognosis of LCPD are still not completely understood. In the recent past, different surgeons have proposed different studies about LCPD and the prognosis of this disease. Those studies used different indicators to determine the prognosis of the LCPD. The most common parameters, which are used for the determination of the prognosis of LCPD, are age at first diagnosis, the extent to which the femoral head is involved, calcification on the lateral aspect, the extent to which the femoral head is lateralized, extent to which head of femur is uncovered, extent to which head of the femur is widened, the extent to which physis of the femur is horizontally aligned, and the gage sign.

But still, the age, at which the disease is first diagnosed and the extent to which the femoral head is involved are the indicators that are most commonly used for the determination of prognosis of LCPD [910]. In literature, because of previous research, it is believed that if the patients are diagnosed under age six, they usually show a good prognosis, as they get enough time for bone growth and remodeling of bone.

Different treatment options have been proposed for managing LCPD. Conservative treatment includes bed rest, physiotherapy, bracing or casting and in rare cases adductor tenotomy [11-13]. Surgical treatments include osteotomies at the femoral [1415] or pelvic [1617] level. The main aim of the treatment is to get the full range of motion of the hip joint, femoral head

containment [18, 19] and maintenance of the normal shape of the femoral head [3, 4, 20].

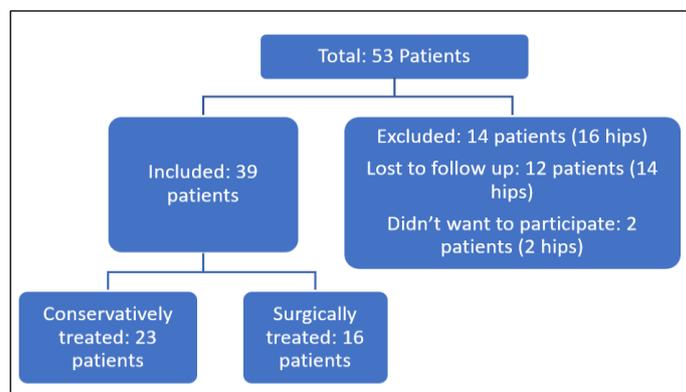
The overall main purpose of this study is to add some knowledge on the treatment of LCPD, with a main focus on comparison between conservative and surgical treatments of Legg-Calve-Perthes Disease (LCPD). And a brief overview of the complications of these treatments. Our main hypothesis was that surgically treated LCPD patients have much better outcomes in comparison with those who were conservatively treated.

MATERIALS AND METHODS

This study was conducted at the joint surgery department of our hospital. The main method which was used in this study was a Cohort study, in a retrospective fashion.

The patients who suffered from Perthes disease were invited for detailed examination. The patients, who were included in this study, were treated between 2005 to 2020. Initially, a total number of 53 patients were included in this study. 14 out of 53 patients, couldn't be contacted due to loss of contact or they didn't want to participate in this study. So, the total number of students who were included in this study was 39 (Flow Chart).

Flow Chart



The patients were first diagnosed at the age of 5 to 8 years of their age. Different classification systems have been proposed to check the severity of the disease, but in our study, we mainly used Stulberg's classification system. Patients were divided into two groups based on the treatment which they went through. The main surgical treatments that were used in these patients were osteotomies and conservative treatment mainly involved POP (Plaster of Paris) casting, bracing and bed rest, to alleviate the pressure on the femoral head. The total number of patients who were treated conservatively was 23. Out of these 23 patients, 17 patients were male and 6 patients were female. These patients were assigned to group I. The mean age of onset of Legg-Calve-Perthes Disease (LCPD) was 6.5 in these patients. Surgically

treated patients assigned to group II. The number of patients who were included in these patients was 16. The main treatment which was used in this group was osteotomy of the femur. The number of patients, who were treated surgically, was 16. Out of these 16, 4 were female patients and 12 were males. The follow-up period in these patients was 3 to 6 years. The mean age of onset of disease in these patients was 6.6 years. The follow-up period in these patients was 7 to 10 years.

The main treatments that were used for patients in group I, conservatively treated patients were POP casting, bracing and bed rest. The main purpose of this type of treatment was to relieve the patients from pressure on the femoral head, which underwent necrosis due to vascular insult. The patients were prohibited from

exercises, which can prevent the femoral head from further damage. The average duration of bracing and bed rest was 18 months. But after every 6 months, the patient was asked to come for a follow-up in our clinic to

observe the course of the disease. The main ways of evaluation that were used for follow-up were clinical assessment and Antero-posterior radiographs. Details of conservatively treated patients are given in Table 1.

Table 1: Clinical and radiological data of conservatively treated patients

No	gender	mean follow-up (years)	Harris Hip score	CE Angle 1	CE Angle 2	CCD angle 1	CCD angle 2	Stulberg
1	M	2	44	18	30	130	130	3
2	M	2	80	23	30	130	135	3
3	M	8	46	21	14	110	120	4
4	M	7	60	25	20	135	122	3
5	M	3	45	30	31	115	125	3
6	F	5	50	18	30	126	138	2
7	M	5	46	23	25	125	135	4
8	M	6	40	23	28	121	130	5
9	M	3	39	20	23	125	130	5
10	M	2	50	11	16	155	151	5
11	F	7	70	8	13	135	145	5
12	M	8	40	17	40	126	107	3
13	F	3	44	13	21	108	119	3
14	M	4	72	15	19	143	152	4
15	M	4	48	10	18	107	125	3
16	M	7	50	23	35	129	115	5
17	F	4	60	18	26	125	140	2
18	M	3	48	20	28	130	145	3
19	F	4	69	23	29	128	148	2
20	M	3	42	11	23	110	135	4
21	M	4	56	30	37	120	143	2
22	M	6	76	27	40	130	150	2
23	F	3	40	18	15	128	130	4

M: Male, F: Female, CE Angle: Central Edge Angle, CCD Angle: Caput-Collum-Diaphyseal Angle

The patients in group II, surgically treated patients, underwent osteotomies by experienced Orthopaedic Surgeons at the first affiliated hospital of Xinjiang Medical University. Before surgery, radiographs in the AP position were taken. These radiographs were taken in internal rotation and abduction positions, to confirm the degree of correction needed.

Surgery was performed by acquiring the lateral position. After the surgery, spica casting was used for the stabilization of the hip for 7 to 8 weeks. The application of spica casting was also useful for protecting the hips from weight bearing. The fixation material was removed at about 18 months after surgery. Details of surgically treated patients are given in Table 2.

Table 2: Clinical and radiological data of surgically treated patients

No	Gender	mean follow-up (years)	Harris Hip score	CE Angle 1	CE Angle 2	CCD Angle 1	CCD Angle 2	Stulberg
1	M	6	76	21	28	130	130	4
2	M	5	80	18	31	125	128	3
3	F	6	78	14	30	120	105	4
4	M	4	76	12	30	130	130	3
5	M	4	71	15	29	125	135	4
6	M	5	81	10	30	120	120	5
7	M	5	81	18	25	115	130	4
8	F	3	78	12	28	125	135	5
9	M	6	82	19	30	130	140	4
10	F	5	75	9	25	120	138	5
11	M	5	84	20	30	135	138	3
12	M	4	79	13	29	125	135	5
13	M	5	83	21	32	135	133	3
14	M	3	86	24	35	129	132	3
15	F	5	72	11	26	110	140	5
16	M	6	78	14	25	120	137	5

M: Male, F: Female, CE Angle: Central Edge Angle, CCD Angle: Caput-Collum-Diaphyseal Angle

For clinical assessment, patients underwent a series of questionnaires. For the evaluation of hip

function, a modified form of Harris Hip score was used. In this scoring system, the score was given according to the range of motion of the hip joint and the different range of mobilities acquired by the patient's ability, at the hip joint.

For radiological assessment, radiographs were taken anteroposteriorly and laterally. The radiographs were taken, preoperatively and at the time of final investigation. The main criteria that were used for radiological evaluation included CCD angle (femoral neck-shaft angle) and CE (center edge angle or Wiberg's centre-edge angle). CCD angle 1 was used to determine the femoral neck shaft angle preoperatively and CCD angle 2 was used to determine the femoral neck shaft angle post-operatively. CE1 was used to determine the center edge angle preoperatively and CE2 was used to determine the center edge angle post-operatively. The staging system which was used in this study is Stulberg's classification. This classification system mainly includes the characteristic appearance of the femoral head (spherical, ovoid/ mushroom-shaped, flat or incongruent). It's also used for the determination of the prognosis of the disease and the proper treatment plan, depending on the stage of the disease.

According to Stulberg's classification, the patients in group I 4 patients were assigned to class II, 8 patients belonged to class III, 5 patients were classified as class IV and 5 patients were placed in class V. According to Stulberg's classification of group II, 5 patients were classified as class III, 5 patients were placed in class IV and 6 patients were classified as class V.

Statistical Analysis: Data analysis was done by using the SPSS 23.0 version. A simple t-test was used for statistical analysis.

RESULTS

The patients in group II were well satisfied with their hip mobility. Surgically treated patients had good hip functions and they had no limitations. About 60 percent of the patients in group I were well satisfied with their hip functions but 40 percent of patients were still complaining of pain and restricted motion. The pain was relieved by resting and using analgesics. According to clinical assessment surgically treated patients had better quality of life than patients with conservative treatment. Complete data of patients of the two groups is given in Table 1 and Table 2. According to the modified form of the Harris Hip score, the mean value of group I was 52.8 and the mean value of group II was 78.7. The mean value of CCD angle 1 in group I, before treatment, was 125.7° and the mean value of CE1 was 19.3°. The mean value of CCD angle 2 in group I, at the time of final investigation, was 133.48° and the mean value of CE2 of this group, at the time of final investigation, was 25.70°.

The mean value of CCD angle 1 in group II, before treatment, was 124.63° and the mean value of CE1 was 15.69°. The mean value of CCD angle 2 in group II, at the time of the final investigation, was 131.63° and the mean value of CE2 of this group, was 28.94°.

There was only a difference of 1.1° in the means of group I and group II CCD angles 1. Which is considered almost the same. The mean of CCD angle 2 was 1.9° higher in group I than that in group II. Which is also considered almost the same. The mean value of CE1 in group I was 3.6° greater than that in group II. The mean value of CE2 in group I was less than in group II. The total difference of degrees in these means was 3.2°. Statistical results of these two groups are given in Table 3.

Table 3: A statistical result of the two groups (Group I conservatively treated and Group II surgically treated). The result mainly focused on the radiological findings like CE angle and CCD angle of hip joint

Angles	CE (Conservative) Mean ± sd.	CCD (Conservative) Mean ± sd.	CE (Surgically treated) Mean ± sd.	CCD (Surgically treated) Mean ± sd.
Before treatment (CE1 and CCD1)	19.35±6.09	125.70±2.33	15.69±4.51	124.63±6.90
Final check (CE2 and CCD2)	25.70±8.00	133.48±12.28	28.94±2.74	131.63±8.76
t	4.69	3.22	14.13	2.70
p	0.000	0.004	0.000	0.016

CE Angle: Central Edge Angle, CCD Angle: Caput-Collum-Diaphyseal Angle, sd: standard deviation

According to Stulberg's classification, the patients in group I 4 patients were assigned to class II, 8 patients belonged to class III, 5 patients were classified as class IV and 5 patients were placed in class V. According to Stulberg's classification of group II, 5 patients were classified as class III, 5 patients were placed in class IV and 6 patients were classified as class V.

According to the statistical results of the data, shown above in the statistical table, there is no significant statistical difference between the outcomes of surgical and conservative treatments, as P-values for both conservatively treated and surgically treated patients were significant (<0.05).

DISCUSSION

Our study mainly focused on the comparison between outcomes of conservative and surgical treatment of patients with Legg-Calve-Perthes Disease (LCPD). According to statistical results of data, based on radiograph measurements, we concluded that there is no significant difference between conservative and surgically treated patients. However, according to our clinical assessment, we found that the quality of life of surgically treated patients was better than those who were treated conservatively. This clinical result in conservatively treated patients might be due to psychological stress, restricted lifestyle or due to less physical activity than those patients who were surgically treated.

The main aim of the treatment of LCPD is to maintain the spherical shape of the femoral head in the acetabulum, but there is still no official recommendation for the treatment of LCPD. A common trend that is being used for the treatment of LCPD is that patients <6 years of age are treated conservatively and patients above age 6 years and with late stage of the disease are treated surgically [21]. Several studies have been conducted on conservative and surgical treatments and the outcomes of these treatments. A study, presented by Petrie *et al.*, [21], showed that using plasters in patients with LCPD had 60% good results. In his study, the mean age at the beginning of LCPD was 7 years. Another study which was conducted by Curtis and his fellows [23] showed a 63% good result by using braces. In his study, the mean age was 8.5 years. In previous studies, mentioned above, the femur of the head was widely involved, and the age at which the disease started was ≥ 5 years.

A treatment plan was introduced by Herring for treating LCPD [24]. The patients who belonged to group A, of lateral pillar classification, were suggested not to go for surgical treatment, but to go for conservative treatment, mainly for symptom improvement. The same treatment plan was suggested for the patients who belonged to group B, of lateral pillar classification, and their age at the time of diagnosis was six or less than six years. The patients, who belonged to group C, of lateral pillar classification, and their age at the time of diagnosis was more than six years, were recommended to go for surgical treatment like osteotomies. In another research, it was provided that the patients whose first diagnosis was made at an age of less than 8 years, showed good outcomes, no matter which kind of treatment they had. However, the patients who belong to group C, of lateral pillar classification, will have a poor prognosis, no matter at which age they diagnose. According to the modified form of lateral pillar classification, patients who are classified as class A don't require any treatment and the prognosis of this class is good. The patients who are classified as class B require conservative treatment if diagnosed under eight years of age, and patients who are diagnosed at more than eight years of age, require

osteotomies like innominate or varus femoral. The prognosis of this group depends on different Stulberg's classes. Stulberg's class I show a good prognosis but Stulberg's class IV shows a poor prognosis. Patients who belong to class B/C require osteotomies if they are diagnosed after eight years of age. The prognosis of this class also depends on Stulberg's class to which it belongs. Stulberg's class I show a relatively good prognosis but Stulberg's class IV shows a poor prognosis. According to the Lateral pillar classification class C patients should be treated non-surgically. The treatment plan for class C differs according to different research. The Prognosis of class C also depends on Stulberg's class, but the prognosis of class C is worse.

In the past, many surgical techniques have been introduced. Indications and outcomes of that surgical treatment vary [24]. A study, conducted by Coates and his fellows [24], showed 58% good results for surgically treated patients. The treatment used for those patients was osteotomy of the proximal end of the femur. The mean age of the patients, used in his study, was around six years and four months. Another study, which was conducted by Paterson and fellows [27], showed a 56% good result. The main surgical treatment used in his study was innominate osteotomy. The mean age of the patients who were involved in that study was five years and ten months.

All the studies, which are mentioned above, showed the same results for conservative and surgically treated patients, according to the stage of disease. The previous studies suggested that patients with Stulberg's class I and II should be treated conservatively and patients with Stulberg's class III, IV and V should be treated surgically. However, in our study, the radiological assessment shows that there is no significant difference between the outcomes of conservative and surgically treated patients. Previously, studies were done on the comparison of conservative treatment, by using Orthosis, and surgical treatment, through different osteotomies. The results of those studies showed similar outcomes in both groups [27-27].

Although different treatment strategies have been introduced in the past, all those treatments do not lack long-term complications. Most of the previous studies, which were conducted on LCPD treatment, showed that there is no significant difference between the outcomes of conservative and surgically treated patients, but still some studies showed that conservatively treated patients showed less favorable results. In one study, by Perpich *et al.*, it was reported that 7 % of those patients, who undergo conservative treatment for LCPD, will need Total Hip Arthroplasty (THA) in the future [27]. In another study by Froberg *et al.*, it was reported that 13% of patients, who were treated conservatively, will need THA in the future [27]. Patients who were treated conservatively had low quality of life and those patients who were treated surgically had better quality of life. In

literature, it has been reported that surgically treated patients still may need Hip arthroplasty in the future.

Still, shortcomings exist in our research, as the number of patients is less and the lack of complete data provided by the patients and due to short follow-up duration. Still, further studies are required to give detailed information about the LCPD etiology, pathophysiology and the more proper and appropriate treatment plan for the LCPD. For the improvement of the quality of life of patients with LCPD, earlier diagnosis and the most appropriate treatment are required to be designed. Further studies are required to evaluate, whether LCPD is a localized disease or also has systematic manifestations as the main reason for LCPD is a vascular insult. So further studies are required to shed light on the etiology, for a better prognosis of this disease.

CONCLUSION

From the data, collected from patients, and statistical calculation of that data, we concluded that there is no significant difference between outcomes of conservative and surgical treatment in patients with Legg-Calve-Perthes Disease (LCPD). So conservative treatment can be suggested for patients with LCPD. But still, further studies are required to shed light on the treatment of LCPD. Because clinically the quality of life of conservatively treated patients is still lower than that with surgically treated patients, though radiologically there is no significant difference between these two modes of treatments.

REFERENCES

- Gower, W. E., & Johnston, R. C. (1971). Legg-Perthes disease. Longterm follow-up of thirty-six patients. *J Bone Jt Surg Am* 1971(5), 759–768.
- Kelly, F. B. Jr, Canale, S. T., & Jones, R. R. (1980) Legg-Calvé-Perthes disease. Long-term evaluation of non-containment treatment. *J Bone Jt Surg Am*, 1980(62), 400–407.
- Stulberg, S. D., Cooperman, D. R., Wallensten, R. (1981). The natural history of Legg-Calvé-Perthes disease. *J Bone Jt Surg Am*, 1981(63), 1095–1108.
- Catterall, A. (1971). The natural history of Perthes' disease. *J Bone Jt Surg Br*, 1971(53), 37–53.
- Herring, J. A., Kim, H. T., & Browne, R. (2004). Legg-Calve-Perthes disease. Part I: classification of radiographs with use of the modified lateral pillar and Stulberg classifications. *J Bone Joint Surg Am*, 86, 2103–2120.
- Ippolito, E., Tudisco, C., & Farsetti, P. (1985). Long-term prognosis of Legg-Calvé-Perthes disease developing during adolescence. *J Pediatr Orthop*, 5(6), 652–656. doi: 10.1097/01241398-198511000-00004.
- Morcuende, J. A., Dolan, L. A., Dietz, F. R., & Ponseti, I. V. (2004). Radical reduction in the rate of extensive corrective surgery for clubfoot using the Ponseti method. *Pediatrics*, 113(2), 376–380. doi: 10.1542/peds.113.2.376. [PubMed] [CrossRef] [Google Scholar]
- Karimi, M., & McGarry, T. (2012). A comparison of the effectiveness of surgical and non-surgical treatment of Legg-Calve-Perthes disease: a review of the literature. *Adv Orthop*, 2012, 490806.
- Ippolito, E., Tudisco, C., & Farsetti, P. (1987). The long-term prognosis of unilateral Perthes' disease. *J Bone Joint Surg Br*, 69(2), 243–250. [PubMed] [Google Scholar]
- Skaggs, D. L., & Tolo, V. T. (1996). Legg-Calve-Perthes disease. *J Am Acad Orthop Surg.*, 4(1), 9–16. [PubMed] [Google Scholar]
- Fulford, G. E., Lunn, P. G., & Macnicol, M. F. (1993). A prospective study of nonoperative and operative management for Perthes' disease. *J Pediatr Orthop*, 13(3), 281–285. doi: 10.1097/01241398-199305000-00001. [PubMed] [CrossRef] [Google Scholar]
- Ingman, A. M., Paterson, D. C., & Sutherland, A. D. (1982). A comparison between innominate osteotomy and hip spica in the treatment of Legg-Perthes' disease. *Clin Orthop Relat Res.*, 163, 141–147. [PubMed] [Google Scholar]
- Jani, L. F., & Dick, W. (1980). Results of three different therapeutic groups in Perthes' disease. *Clin Orthop Relat Res*, 150, 88–94. [PubMed] [Google Scholar]
- Axer, A., Gershuni, D. H., Hendel, D., & Mirovski, Y. (1980). Indications for femoral osteotomy in Legg-Calvé-Perthes disease. *Clin Orthop Relat Res*, 150, 78–87. [PubMed] [Google Scholar]
- Axer, A., Schiller, M. G., Segal, D., Rzetelny, V., Gershuni-Gordon, D. H. (1973). Subtrochanteric osteotomy in the treatment of Legg-Calvé-Perthes' syndrome (L.C.P.S.) *Acta Orthop Scand*, 44(1), 31–54. doi: 10.3109/17453677308988671. [PubMed] [CrossRef] [Google Scholar]
- Klisić, P., Bauer, R., Bensahel, H., & Grill, F. (1985). Chiari's pelvic osteotomy in the treatment of Legg-Calvé-Perthes disease. *Bull Hosp Jt Dis Orthop Inst.*, 45(2), 111–118. [PubMed] [Google Scholar]
- Kruse, R. W., Guille, J. T., & Bowen, J. R. (1991). Shelf arthroplasty in patients who have Legg-Calvé-Perthes disease. A study of long-term results. *J Bone Joint Surg Am*, 73(9), 1338–1347. [PubMed] [Google Scholar]
- Grasemann, H., Nicolai, R. D., Patsalis, T., & Hövel, M. (1997). The treatment of Legg-Calvé-Perthes disease. To contain or not to contain. *Arch Orthop Trauma Surg.*, 116(1–2), 50–54. doi: 10.1007/BF00434101. [PubMed] [CrossRef] [Google Scholar]
- Grzegorzewski, A., Bowen, J. R., Guille, J. T., & Glutting J. (2003). Treatment of the collapsed femoral head by containment in Legg-Calve-Perthes disease. *J Pediatr Ortho*, 23(1), 15–19. [PubMed] [Google Scholar]

20. Mindell, E. R., & Sherman, M. S. (1951). Late results in Legg-Perthes disease. *J Bone Joint Surg Am*, 33(A:1), 1–23. [PubMed] [Google Scholar]
21. Nguyen, N.-A.T., Klein, G., Dogbey, G., McCourt, J. B., & Mehlman, C. T. (2012). Operative Versus Nonoperative Treatments for Legg-Calvé-Perthes Disease: A Meta-Analysis. *J. Pediatr. Orthop.*, 32, 697–705. [Google Scholar] [CrossRef] [PubMed]
22. Petrie, J. G., & Bitenc, I. (1971). The abduction weight-bearing treatment in Legg-Perthes disease. *J Bone Joint Surg [Br]* 53, 54–62.
23. CURTIS, B. H., GUNTHER, S. F., GOSSLING, H. R., & PAUL, S. W. (1974). Treatment for Legg-Perthes disease with the Newington ambulation-abduction brace. *JBJS*, 56(6), 1135-1146.
24. Herring, J. A., Kim, H. T., & Browne, R. (2004). Legg-Calvé-Perthes disease. Part II: Prospective multicenter study of the effect of treatment on outcome. *J Bone Joint Surg*, 86-A, 2121–2134. [PubMed] [Google Scholar]
25. Reddy, R. R., & Morin, C. (2005). Chiari Osteotomy in Legg–Calvé–Perthes Disease. *J. Pediatr. Orthop. B*, 14, 1–9. [Google Scholar] [CrossRef] [PubMed]
26. Coates, C. J., Paterson, J. M., Woods, K. R., Catterall, A., & Fixsen, J. A. (1990). Femoral osteotomy in Perthes' disease. Results at maturity. *The Journal of Bone & Joint Surgery British Volume*, 72(4), 581-585.
27. Paterson, D. C., Leitch, J. M., & Foster, B. K. (1991). Results of innominate osteotomy in the treatment of Legg-Calve-Perthes disease. *Clin Orthop*, 266, 96–103.
28. Evans, I. K., Deluca, P. A., & Gage, J. R. (1988). A comparative study of ambulation-abduction bracing and varus derotation osteotomy in the treatment of severe Legg-Calvé-Perthes disease in children over 6 years of age. *Journal of Pediatric Orthopaedics*, 8(6), 676-682.
29. Kim, H. K. W. (2010). Legg-Calvé-Perthes' disease. *Journal of the American Academy of Orthopaedic Surgeons*, 18(11), 676–686.
30. Terjesen, T., Wiig, O., & Svenningsen, S. (2010). The natural history of Perthes' disease: risk factors in 212 patients followed for 5 years. *Acta orthopaedica*, 81(6), 708-714.
31. Perpich, M., McBeath, A., & Kruse, D. (1983). Long-Term Follow-up of Perthes Disease Treated with Spica Casts. *J. Pediatr. Orthop.*, 3, 160–165. [Google Scholar] [CrossRef] [PubMed]
32. Froberg, L., Christensen, F., Pedersen, N. W., & Overgaard, S. (2011). The Need for Total Hip Arthroplasty in Perthes Disease: A Long-Term Study. *Clin. Orthop.*, 469, 1134–1140. [Google Scholar] [CrossRef] [PubMed] [Green Version]