Early outcomes of one-stage combined osteotomy in Legg-Calve´-Perthes disease

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Abstract

Background: Legg-Calve´-Perthes disease (LCPD) is an idiopathic avascular necrosis of the femoral head. There are multiple approaches to the treatment of LCPD ranging from conservative management to a wide variety of surgical methods. Conservative management necessitates extreme degrees of abduction in an orthosis for a longer period of time which further jeopardize capital femoral head vascularity. Surgical containment methods are used in cases where it is desirable. Initial surgical containment methods are varus or varus-derotational osteotomy of the proximal femur or an innominate osteotomy as described by Salter and other pelvic osteotomies. The purpose of this study was to describe the early results of containment methods by one-stage combined osteotomy (femoral varus osteotomy and Salter innominate osteotomy) in patients with severe LCPD.

Materials and Methods: 23 children were operated in the age group of 4–9 years for LCPD by one-stage combined osteotomy procedure between January 2005 and June 2012. There were 19 boys and 4 girls, left hip involved in 10 cases and right in 13 cases. Preoperatively, they were classified according to Catterall, Joseph's stage and lateral pillar (LP) classification. Postoperatively, clinical results were evaluated in accordance with Ratliff classification and radiological assessment was made by Mose's index, modified Stulberg classification and Epiphyseal extrusion index.

Results: Seventeen hips were Catterall group III, 6 in group IV and all had two or more "head-at-risk" signs. There were 2 patients with stage IIA, 15 were in stage IIB and 6 were in stage IIIA as classified by Joseph's stage of disease. According to LP classification, 11 patients were group B, 3 were group B/C and 9 were in group C. At an average followup of 5.4 years (range 2–9.5 years), the clinical results were good in 12, fair in 9 and poor in 2. According to Mose scale, 8 patients had good results, 13 fair results and 2 had poor results. Based on modified Stulberg classification, there were 10 patients in group A, 11 in group B and 2 in group C. The average preoperative extrusion index was 23.6% which improved postoperatively to 9.5% at latest followup.

Conclusions: The surgical treatment of LCPD with the best expected outcome is still a challenge. Advanced containment methods by one-stage combined osteotomy can be considered as an alternative treatment where femoral head subluxation or deformity which makes containment difficult or impossible by more conventional methods.

Key words: Femoral osteotomy, legg-Calve´-Perthes disease, paediatric hip, pelvic osteotomy, surgical containment

MeSH terms: Osteotomy, femur, legg-calve-perthes disease, leg perthes disease, pelvis

Introduction

Legg-Calve-Perthes disease (LCPD) is an aseptic, noninflammatory, self-limited condition of the immature hip characterized by idiopathic osteonecrosis of the femoral epiphysis, followed by a subchondral fracture, fragmentation, revascularization

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and remodeling.[1-4] It is associated with both substantial hip pain and dysfunction during the disease process as well as later in adulthood.[5] If treatment is not initiated early in the disease process eventual flattening and subluxation of the hip joint occurs.

The main purpose of the management of LCPD is to prevent the deformity of the femoral head and the secondary degenerative osteoarthritis. The goal of intervention in LCPD has been to prevent femoral head deformation by containing the head within the acetabulum, using it as a mold for guiding femoral head development.[6]

Containment treatment in LCPD is to hold the femoral head in the acetabulum during the period of “biologic plasticity” while necrotic bone resorbed and living bone is restored through the process of “creeping substitution.” Improvement of containment can be obtained with abduction splints, Petrie casts, arthrodiastasis, femoral osteotomies (proximal femur varus or varus derotational osteotomy) or pelvic osteotomies (Salter, Chiari, Shelf, Triple).[7-15] They are having their own drawbacks and often ineffective in severe cases of LCPD where femoral head enlargement and lateral subluxation are present.

The first advanced containment method, a combination of proximal femoral varus osteotomy and Salter’s innominate osteotomy was performed by Craig and Kramer for the treatment of severe LCPD with lateral subluxation of the hip.[16] This combined procedure has the advantage of maximize containment of femoral head within acetabulum which are not containable by pelvic or femoral osteotomy alone. It also avoids individual complications of each procedure if conducted simultaneously in a single stage.[17]

This study evaluates the clinical and radiographic outcomes obtained with advanced containment methods by one-stage combined osteotomy in patients with severe LCPD.

Materials and Methods

23 children were operated for LCPD by one stage combined osteotomy procedure between January 2005 and June 2012. There were 19 (83%) boys and 4 (17%) girls, 10 (43%) left hips and 13 (57%) right hips. The age at the onset of symptoms (limp, pain or both) prior to diagnosis ranged from 3.5 to 8 years with an average of 6.1 years.

The parameters evaluated preoperatively were presenting symptoms, range of motion of the affected hip, Waldenstr¨om disease stage, Joseph stage, Catterall group, lateral pillar (LP) group and “head-at-risk” signs. At preoperative clinical assessment, all patients were noted to have a painful limp and a limited range of motion, especially abduction and internal rotation.

Antero-posterior (A-P) and Lauenstein lateral radiographs of the pelvis taken at the first visit of the patient were used for assessment of the stage of the disease and extent of involvement of the femoral head. Radiographic staging of the disease was determined by the classification of Waldenstr¨om and Joseph; the extent of involvement was evaluated according to the classifications of Catterall and LP groups.[18-22] The radiological signs of head-at-risk consisting of Gage sign, calcification lateral to the epiphysis, lateral subluxation, diffuse metaphyseal reaction and horizontal growth plate were examined in all patients. The coverage of the femoral head was assessed by measuring epiphyseal extrusion index before surgery and at final followup.[23] Magnetic resonance imaging was performed on 15 patients who displayed the typical flattening and lateral extrusion of the femoral capital epiphysis.

Clinically, patients were graded at the time of their most recent followup using criteria adapted from Ratliff which categorized the results as good (>18 points), fair (15–17 points), poor (14–11 points) and bad (<10 points) using four parameters (pain, activity, range of movements and radiological appearance) [Table 1].[24]

The final results of femoral head sphericity were classified according to Mose’s method.[25] It measures the sphericity of femoral head in the A-P and Lauenstein lateral projections by superimposing a template with concentric rings. The result was considered good if the contour of the femoral head fits perfectly into the same circle on both views with no deviation of the concentric rings. When the contour of the femoral head fits between two adjacent circles (2 mm variation) on both views, it considered as fair and if the contour of the femoral head touches more than two adjacent circles (>2 mm variation) it is considered as poor.

At followup, the hips were classified according to Stulberg *et al*. as modified by Neyt *et al*.[6,26] The Stulberg classification, which originally contained 5 classes, was modified into a three-group classification, where hips in group A (Stulberg classes I and II) had spherical femoral heads, those in group B (Stulberg III) had ovoid femoral heads and hips in group C (Stulberg classes IV and V) had flat outlines of the femoral head.

Inclusion criteria are patients with Catterall group III, IV with head-at-risk signs and LP group B, B/C and C. Children suffered with hip infection, multiple epiphyseal dysplasia, developmental dysplasia of hip, hematologic disorder,

Table 1: Ratliff's clinical evaluation

Points	Pain	Activity	Movement	Radiographic appearance
1	Severe	Walks short distance only, with difficulty	Little or none	Gross evidence of osteoarthritis, with severe loss of "joint space"
2	Severe on movement; little at rest	Walks half a mile	<50%; fixed deformity	Completely distorted head, only partly contained; no neck; occasionally greater trochanter above the level of the head; "joint space" good
3	Moderate; limits activity	Walks two miles	More than 50%; no fixed deformity	Very flattened head, incompletely contained; very short neck; occasionally early sclerosis of the acetabulum
4	Slight ache after prolonged standing; does not limit activity	Walks long distances, but cannot do heavy work or play games	Slight limitation	Slightly flattened head; fully contained; slightly short neck
5	None	Normal	Full	Normal or almost normal appearance

steroid therapy, hypothyroidism, juvenile arthritis, diabetes, ranal failure, metabolic or neoplastic disease and failure to follow protocol were excluded from the study.

The range of motion of the hip joint should be restored prior to surgery as adduction contracture is a relative contraindication for osteotomy.[27,28]

An initial period of traction is used for 1–2 weeks to overcome muscle spasm and improve the range of hip movement. Adductor tenotomy is recommended for patients with persistent loss of motion at the hip joint. Preoperative A-P radiographs in full internal rotation and abduction were used to evaluate the adequacy of containment of the hip joint. The approximate varus angle was determined according to the best-fit position of the hip in internal rotation and abduction radiographs. If in A-P radiograph with abduction 40° could not give an adequate containment then a combined osteotomy procedure was planned. In this series, all 23 patients require combined osteotomy procedure for containment of the hip joint.

Operative procedure

All procedures were performed on a standard radiolucent operating table with the patient supine and a bump under sacrum. The affected limb was surgically prepared and draped free. The osteotomies were performed through two separate incisions: A lateral approach to the proximal femur for the sub-trochanteric varus osteotomy and Bikini modification of anterior Smith-Petersen approach for innominate osteotomy [Figure 1a].

The sequence of performing combined one-stage osteotomy is femoral varus osteotomy first followed by innominate osteotomy. Performing a proper femoral osteotomy requires achieving only a modest degree of varus (10°–15°) by removing 1–1.5 cm medial wedge of bone resected from the sub-trochanteric region of femur (with its base medial and its apex lateral). The proximal and distal parts of the femoral osteotomy are fixed with a pre bent dynamic compression plate and screws on lateral aspect [Figure 1b and c].

The surgical technique for innominate osteotomy was described by Salter using a Gigli saw.[29] A full thickness bone graft removed from the anterior part of the iliac crest and is trimmed to the shape of a 30°–35° wedge; the base should correspond approximately to the distance between the anterior superior and inferior spines. After osteotomy, the distal segment of the innominate bone containing the entire acetabulum is shifted forward, downward and outward so that the osteotomy site is opened antero laterally. The bone graft is secured in the osteotomy site and transfixed by two threaded K-wires [Figure 1d and e]. Intra-operative radiographic image intensification was taken to confirm containment, neck shaft angle and pin placement.

The average operating time including application of spica cast was 2 h 52 min (range 2 h 30 min to 3 h 15 min) and with an average estimated blood loss of 350 ml (range 250–450 ml). The postoperative protocol was to keep patients immobilized in hip spica cast for 6–8 weeks followed by a physical therapy program. This physical therapy consisting of stretching exercises of the hips, hamstrings, lower back and strengthening program focusing mainly on the gluteus medius. At 8 weeks postoperatively, the innominate osteotomy pins were removed under general anesthesia. Crutch walking and progression to full weight bearing started when the radiographs show healing of both osteotomies. The femoral fixation plate and screws were removed at 1–1.5 years postoperatively.

Statistical analysis

Data were entered and stored MS Excel® (Microsoft Office 2007, Redmond, Washington, USA) database and then exported to Stata version 12.0 for (StataCorp LP Texas US) analysis. The improvement of mean epiphyseal extrusion index before and after combined osteotomy was compared among different independent variables such as gender, age at onset, age at surgery, Catterall group, Joseph's stage, LP group and number of head-at-risk signs. Paired *t*-test was used for studying the statistical significance of difference between the mean pre and postoperative epiphyseal extrusion index (using Stata version 12.0). A $P < 0.05$ was considered significant.

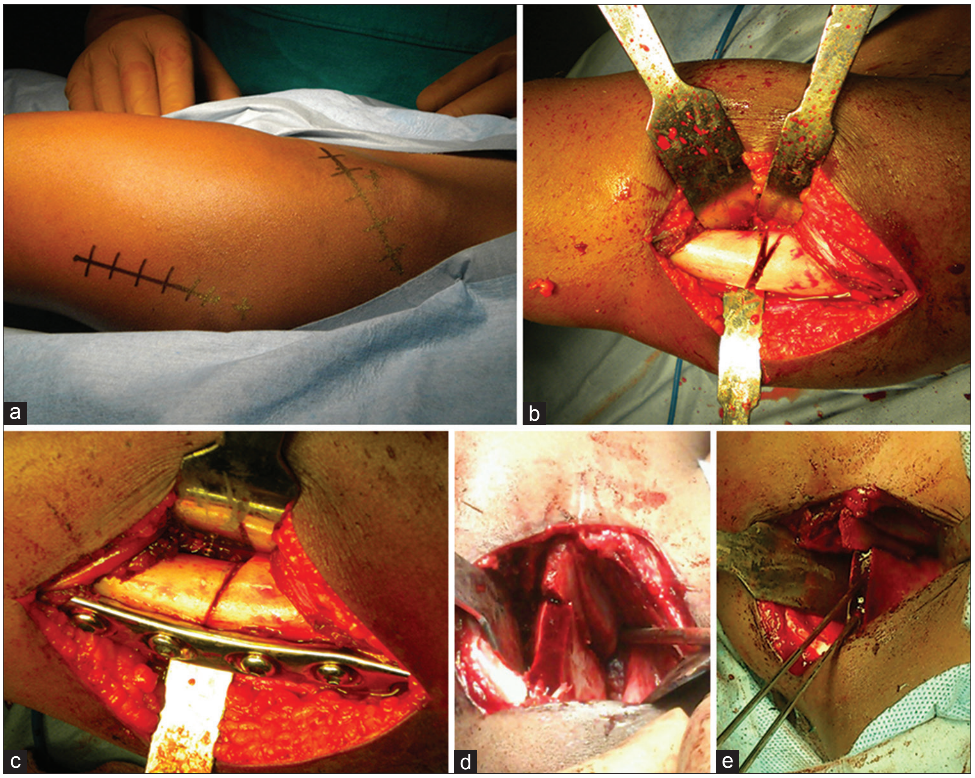

Figure 1: Peroperative photographs showing (a) Position of patient and marking of incisions (b) Close wedge sub-trochanteric osteotomy is performed (c) Osteotomy fixed with a contoured dynamic compression plate and screws (d) Salter's innominate osteotomy is performed through Bikini incision (e) Pelvic osteotomy is fixed with a triangular bone graft and two threaded K-wires

Results

The age at the onset of symptoms (limp, pain or both) ranged from 3.5 to 8 years (average age 6.1 years). The time interval between onset of symptoms and diagnosis varied between 0 and 6 months (average 3 months). The average interval between onset of disease and surgical treatment was 5.7 months (range 2–12 months). Age at time of surgery ranged from 4 to 9 years (average age 6.6 years). The mean length of time between one-stage combined osteotomy and the final assessment of each patient was 5.4 years (range 2-9.5 years) and the average age at followup was 12 years (range 10.4–13.9 years) Table 2.

Fifteen children were treated conservatively varying in duration from few weeks to 9 months with traction, hip spica or weight relieving calipers and in rest eight children had no treatment before surgery. Preoperatively during clinical examination, all 23 hips in this study were showed a decrease in range of motion of affected hip joint and 17 hips had adducted contracture. The shortening of 0.5 cm was noticed in 7 patients.

All patients were in a poor prognostic based on the extent of femoral head involvement, head-at-risk signs, epiphyseal extrusion index and their age at the onset of disease. They were classified radiologically (preoperatively) as Catterall III (n = 17) and Catterall IV (n = 6) stage. The number of radiological signs of head-at-risk for each hip ranged from 2 to 5 (average 3.6). According to Joseph's staging, the hips displayed stage IIA (n = 2), IIB (n = 15) and IIIA (n = 6). The distribution of hips according to LP classification were group B (n = 11), group B/C (n = 3) and group C (n = 9). The amount of lateral epiphyseal extrusion index of the femoral head of the affected hip joint was between 20% and 31% (mean 23.6%, SD 2.52).

At latest followup in accordance with the Ratliff classification, the postoperative clinical results were 12 good (52%), 9 fair (39%) and 2 poor (9%). Two patients developed persistent pain, limited range of motion and femoral head subluxation which leads to poor results. They were treated further later by soft tissue release, revised varus femoral osteotomy and trochanteric epiphysiodesis. According to the Mose criteria of radiological grading index, 8 patients had good results (35%), 13 had fair results (56%) and 2 had poor results (9%). Based on the modified Stulberg classification (Neyt *et al.*), the radiographic outcome at followup was group A in 10 patients (43%), group B in 11 patients (48%) and group C in 2 patients (9%).

The clinical outcome was good in 12 hips (71%) and 5 (29%) had a fair result in Catterall group III patients. In Catterall group IV patients, the results are 4 had fair

Table 2: Clinical details of patients

Case number	Gender	Side affected	Age at onset (years)	Age at surgery (years)	Treatment interval (months)	Catterall group	Joseph stage	Lateral pillar group	Number of head-at-risk signs	Followup interval (years)	Clinical rating (Ratliff)	Mose sphericity rating	Radiological rating (modified Stulberg)	Epiphyseal extrusion index (%)	
														Preoperative	Postoperative
1	Male	Right	7.5	7.9	5	III	IIB	B	3	6.0	Good	Good	A	20	5
2	Male	Left	4.2	4.6	5	IV	IIB	C	4	8.7	Fair	Fair	B	23	12
3	Male	Right	6.0	6.3	3	III	IIB	B	3	6.4	Good	Good	A	22	6
4	Male	Right	3.5	4.0	6	III	IIB	B	2	9.5	Good	Good	A	25	9
5	Male	Left	7.8	8.6	10	III	IIB	B	3	3.4	Good	Fair	B	24	7
6	Male	Right	4.4	5.0	7	IV	IIIA	C	5	7.8	Fair	Fair	B	26	10
7	Male	Right	5.8	6.4	7	III	IIB	B/C	3	6.6	Good	Fair	B	23	5.5
8	Female	Left	6.3	6.6	3	IV	IIB	C	5	4.3	Fair	Fair	B	25	14
9	Female	Right	3.8	4.2	5	III	IIA	B	2	7.6	Good	Good	A	22	6.5
10	Male	Left	6.3	6.4	2	III	IIB	B	3	4.0	Good	Good	A	21	6
11	Male	Right	8.0	9.0	12	IV	IIIA	C	4	2.0	Poor	Poor	C	27	12
12	Male	Left	3.9	4.3	5	III	IIB	B	4	8.2	Good	Good	A	20	5.5
13	Female	Right	5.1	5.7	7	IV	IIIA	C	5	7.3	Poor	Poor	C	31	17
14	Male	Left	7.8	8.4	7	III	IIB	B	4	3.6	Good	Fair	B	23	9
15	Male	Right	4.6	5.0	3	III	IIB	C	4	7.0	Fair	Good	A	23	9.5
16	Female	Right	7.4	8.0	7	III	IIIA	B/C	3	2.7	Fair	Fair	B	24	10
17	Male	Left	6.4	6.9	6	III	IIA	B/C	3	4.9	Good	Fair	A	24	11
18	Male	Left	7.7	8.3	7	III	IIIA	B	4	2.4	Fair	Fair	B	25	16
19	Male	Right	6.9	7.4	6	III	IIB	B	3	4.6	Good	Fair	A	23	8
20	Male	Left	5.7	6.3	8	III	IIB	C	4	5.8	Fair	Fair	B	26	15
21	Male	Right	6.8	7.1	4	III	IIB	B	3	4.3	Good	Good	A	20	5.5
22	Male	Right	7.3	7.5	2	IV	IIIA	C	5	2.4	Fair	Poor	B	22	7
23	Male	Left	6.5	6.9	5	III	IIB	C	4	5.5	Fair	Fair	B	24	12

result (67%) and 2 had poor results (33%). In Joseph group IIA, all 2 patients (100%) had good results. In group IIB, 10 patients had good results (67%) and 5 had fair results (33%). In group IIIA, 4 had fair (67%) and 2 poor results (33%). In LP group B, 10 had good results (91%) and 1 had fair results (9%). In LP group B/C patients, the results are 2 good (67%) and 1 fair (33%). In LP group C patients, the results are 7 fair (78%) and 2 poor (22%).

The average preoperative epiphyseal extrusion index was 23.6% (range 20–31%) which improved postoperatively to 9.5% (range 5–17%). Difference of preoperative and postoperative score was very highly significant in this study ($P < 0.001$, paired t-test) [Table 3].

Nine patients had an age at onset <6 years and rest 14 had more than 6 years. In children under 6 years of age, the clinical results in Catterall group III were considerably better (good - 4, fair - 2) than those in group IV (fair - 2, poor - 1). In children over 6 years of age, the difference was even more pronounced with of Catterall group III hips (good - 8, fair - 3) and in group IV hips (fair - 2, poor - 1). There was also a similar trend of results in Joseph stage and LP groups. Similarly, there are considerably better radiological results in less severe disease and <6 years age groups of Catterall, Joseph and LP groups [Table 4].

The number of girls in this series was small (4 girls; 2 each of Catterall group III and IV, 1 each of IIA, IIB and 2 in IIIA of Joseph stage, 1 each of LP group B, B/C and 2 in C) have demonstrated poor outcome than boys (Ratliff clinical results; 1 good, 2 fair and 1 poor, modified Stulberg radiological results; A-1, B-2, C-1).

Case number 14 is illustrative of good clinical and fair radiological results [Figure 2a-i]. Case number 10 showed good clinical and radiological results [Figure 3a-c], case number 6 showed fair clinical and radiological results [Figure 4a-c] and case number 13 showed poor clinical and radiological results [Figure 5a-c].

Table 3: Change in preoperative and postoperative epiphyseal extrusion index

Epiphyseal extrusion index	Mean	SD
Preoperative	23.61	2.52
Postoperative	9.50	3.61
Change in epiphyseal extrusion index	14.11	2.11

Variables	Number (n=23)	Percentage	Epiphyseal extrusion index		Paired t	df	P
			Mean preoperative	Mean postoperative			
Total	23	100	23.61	9.5	32.06	22	<0.001
Gender							
Female	4	17.39	25.50	11.88	14.44	3	<0.001
Male	19	82.61	23.21	9.00	28.31	18	<0.001
Age at onset (years)							
<6	9	39.13	24.33	10.00	19.23	8	<0.001
>6	14	60.87	23.14	9.18	24.90	13	<0.001
Age at surgery (years)							
<6	7	30.43	24.29	9.93	21.42	6	<0.001
>6	16	69.57	23.31	9.31	24.47	15	<0.001
Catterall group							
III	17	73.91	22.88	8.62	27.52	16	<0.001
IV	6	26.09	25.67	12.00	15.5	5	<0.001
Joseph's stage							
IIA	2	8.7	23.00	8.75	11.40	1	>0.05
IIB	15	65.2	22.80	8.60	25.84	14	<0.001
IIIA	6	26.1	25.83	12.00	13.64	5	<0.001
Lateral pillar group							
B	11	47.83	22.27	7.59	23.58	10	<0.001
B/C	3	13.04	23.67	8.83	10.87	2	<0.05
C	9	39.13	25.22	12.06	20.06	8	<0.001
Number of head-at-risk signs							
2	2	8.70	23.50	7.75	63	1	>0.05
3	9	39.13	22.33	7.11	32.23	8	<0.001
4	8	34.78	23.87	11.37	16.93	7	<0.001
5	4	17.39	26	12	12.96	3	<0.05

SD=Standard deviation

Table 4: Clinical and radiographic outcome (modified Stulberg) in relation to age and severity of femoral head involvement

Femoral head involvement	Clinical outcome						Radiographic outcome					
	Age <6.0 years			Age >6.0 years			Age <6.0 years			Age >6.0 years		
	Good (*n*)	Fair (*n*)	Poor (*n*)	Good (*n*)	Fair (*n*)	Poor (*n*)	A (*n*)	B (*n*)	C (*n*)	A (*n*)	B (*n*)	C (*n*)
Catterall group												
Group III	4	2	0	8	3	0	4	2	0	6	5	0
Group IV	0	2	1	0	2	1	0	2	1	0	2	1
Joseph stage												
Stage IIA	1	0	0	1	0	0	1	0	0	1	0	0
Stage IIB	3	3	0	7	2	0	3	3	0	5	4	0
Stage IIIA	0	1	1	0	3	1	0	1	1	0	3	1
Lateral pillar group												
Group B	3	0	0	7	1	0	3	0	0	5	3	0
Group B/C	1	0	0	1	1	0	0	1	0	1	1	0
Group C	0	4	1	0	3	1	1	3	1	0	3	1

n=Number of patients

Discussion

The decision to treat LCPD surgically is influenced by age of onset of the disease, extent of involvement of the femoral capital epiphysis, radiographic head-at-risk signs and presence and extent of epiphyseal extrusion.[30-34] Among all these factors, extrusion appears to be the most important factor that predisposes to femoral head deformation. If epiphyseal extrusion index is more than 20% there is a very high risk of irreversible femoral head deformation.[23,35] Epiphyseal extrusion is the only factor that can be modulated by containment treatment. In older children extrusion invariably occurs sooner or later in the course of the disease, hence containment is offered as soon as the disease is diagnosed. In younger children, likelihood of extrusion development is uncertain, hence they have to be monitored closely and containment is offered as soon as extrusion is detected.

The modern treatment of LCPD is based on a growing understanding of its natural history. Containment of the femoral head within the acetabulum is currently the preferred method of treatment which can be achieved by either nonoperative or operative methods.[27,35] The main aim of treatment in LCPD is to maintain hip motion while providing containment of the soft femoral head. The principle of femoral head containment was first introduced by Parker and Platt and popularized by Eyre Brook.[36] It refers to repositioning of the anterolateral part of the femoral epiphysis within the confines of the acetabulum to protect the femoral head from being subjected to deforming forces. The "containment" principle along with the biologic plasticity of osteo cartilaginous structures in children allows satisfactory reconstruction and remodeling of the femoral head with time. It prevents lateral migration of the femoral head and thereby avoids flattening while the necrotic bone is being replaced with living bone.[37]

Initial surgical containment methods concentrated on containing the femoral head within the acetabulum by either proximal femoral or innominate osteotomy. Proximal femoral varus osteotomy is a familiar procedure and it offers adequate coverage of femoral head within the acetabulum.[38] It also decompresses the hip joint due to its femoral shortening effect. The disadvantages are limb shortening with prolonged abductor limp and possibility of persistent varus leads to trochanteric prominence.[39] Salter introduced innominate osteotomy as a method of containment to avoid the consequences of femoral osteotomy. The advantage of Salter's innominate osteotomy is better anterolateral coverage of the femoral head without limb shortening or weakness of the abductor mechanism.[40,41] It also displaces the acetabulum medially and increases the lever arm of the abductor muscles, thereby reducing the abductor force required to stabilize the hip.[42] In severe cases of LCPD, salter osteotomy may not allow adequate acetabular rotation to cover the femoral head which leads to iatrogenic hinge abduction.[43]

The use of combined osteotomy as a containment method, in particular for children with more than half of femoral head involvement and the presence of extrusion is considered as the best form of treatment. Advantage of osteotomy is that the duration of the disease can be shortened and it can bypass the stage of fragmentation to attain the regeneration phase.[44,45] Sub-trochanteric osteotomy stimulates retinacular revascularization as it augments blood flow to the femoral head and acetabulum through hypervascularization effect. The addition of pelvic osteotomy stimulates the revascularization of both the acetabulum and the femoral head, thus increasing the recovery process.[46-49] Biological stimulation also enhances acetabular development due to the mechanical pressure from the concentric reduction of the femoral head which has been secured by this operative method.

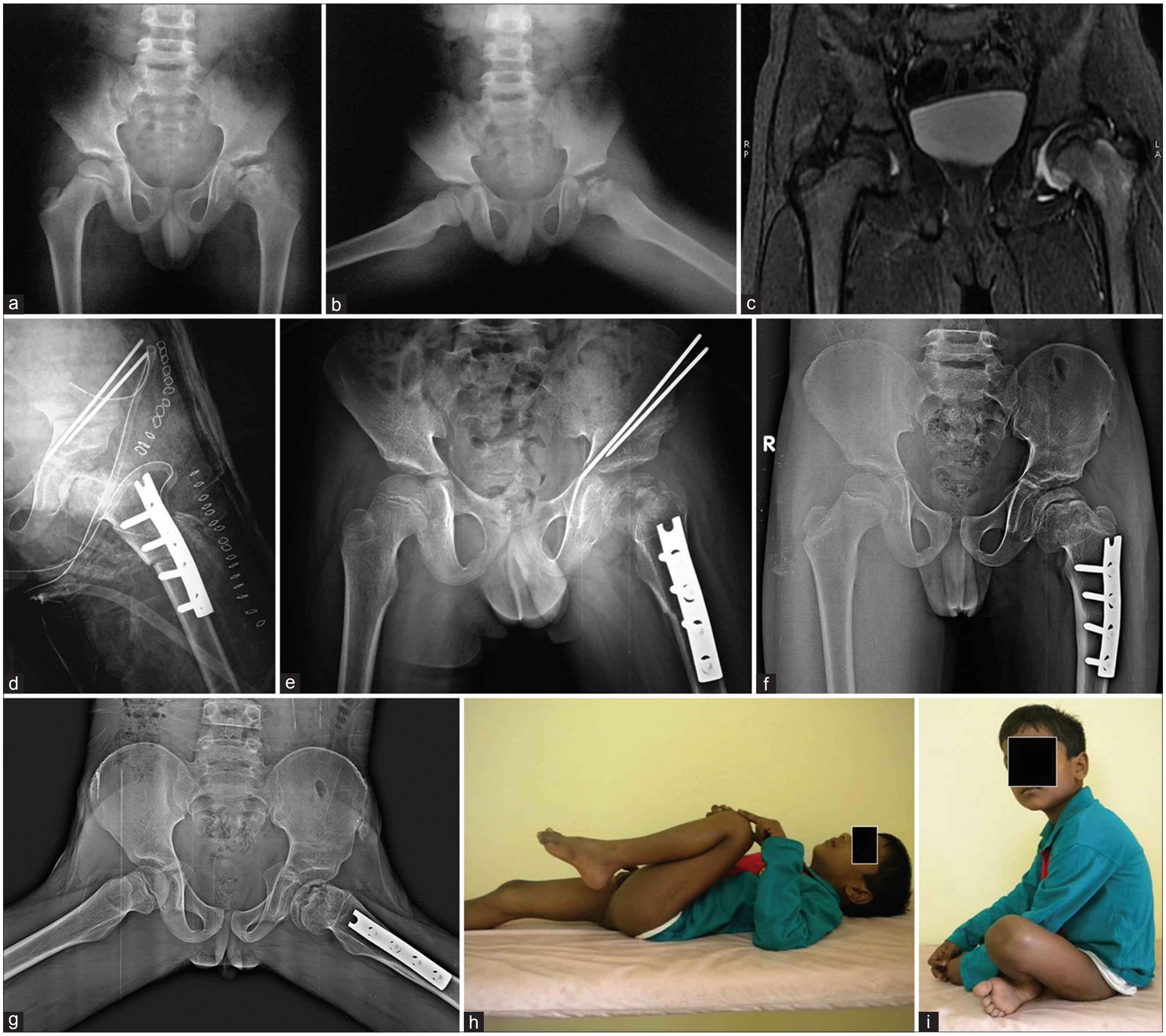

Figure 2: (a) Antero posterior (AP) radiograph of pelvis of a 7 years 10-month-old boy with Legg-Calve-Perthes disease of the left hip demonstrating fragmentation stage of disease (Catterall group III,lateral pillar group B) (b) Lauenstein lateral radiograph showing the extent of head involvement. (c) Coronal magnetic resonance imaging showing avascular necrosis, flattening of epiphysis and lateral epiphyseal extrusion (d) Immediate postoperative AP radiograph showing full containment of the hip joint (e) Six weeks postoperative AP radiograph showing full containment of hip joint (f and g) AP and Lauenstein lateral projection radiograph taken after 1.2 years followup showing both osteotomies are healed and a congruent hip joint (h and i) Clinical photograph showing full flexion of left hip joint and cross-legged sitting

Olney and Asher reported combined osteotomy to treat nine cases of Catterall group III or IV in patients who had average age of 7 years 2 months at disease onset.[50] At an average followup of 50.5 months, 7 patients had good and 2 patients were fair clinical results. There were 3 good, 2 fair and 4 poor results according to Mose criteria of radiographic grading. The authors gave specific indications to make use of double osteotomy, implying that it must be reserved for patients with severe disease in whom containment of the femoral head is difficult to obtain by more conventional methods. They concluded that older patients who would otherwise require a neck-shaft varus angle of 110° or less for containment in the acetabulum were candidates for such a surgery. Chakirgil *et al*. reported 26 patients with severe LCPD in the average age group of 6 years 10 months.[51] At an average followup of 3 years 5 months, they had reported 61.5% good, 23% fair and 15.3% poor results using a combined radiologic and clinical evaluation. By taking all phases of the disease into consideration, the success rate was 84.6%. They have observed best results in cases where the duration of disease was <1 year and age of patients were <7 years old. Crutcher and Staheli reported 14 cases of severe LCPD treated by combined

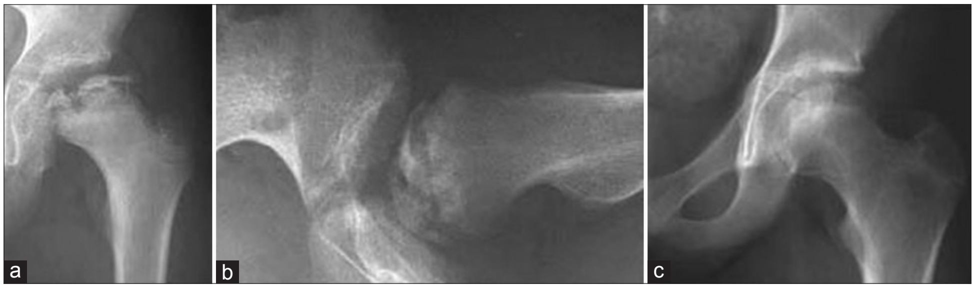

Figure 3: (a) Radiograph of a 6 years 3-month-old boy antero-posterior view showing Catterall group III/lateral pillar group B. (b) Frog leg lateral view showing catterall group III/lateral pillar groups B (c) After 4 years followup showing modified Stulberg A (spherical hip)

Figure 4: (a) Radiograph of a 4 years 5-month-old boy classified as Catterall group IV/lateral pillar group C (b) Frog leg lateral view showing catterall group IV/lateral pillar groups C (c) After 7 years 10 months followup showing modified Stulberg B (ovoid hip)

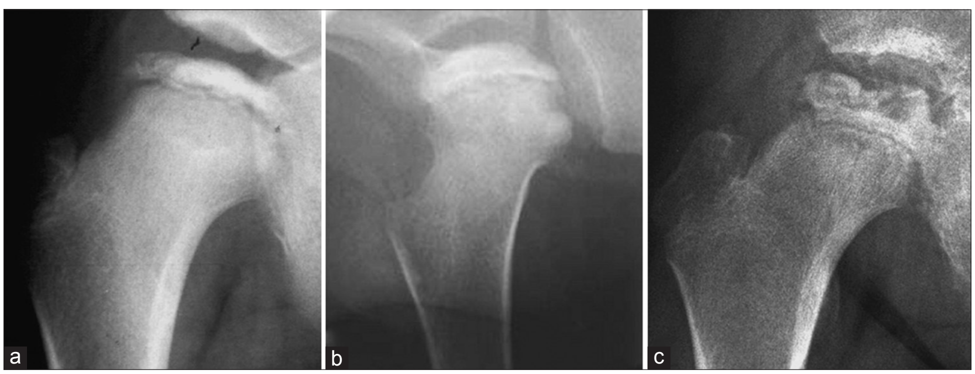

Figure 5: (a) Radiograph of a 5 years 1-month-old girl with Catterall group IV/lateral pillar group C involvement (b) Frog leg lateral view showing catterall group IV/lateral pillar groups C (c) After 7 years 4 months followup showing modified Stulberg C (flat hip)

surgery in the age group of 4–10.5 years.[52] With an average followup of 8 years, they had obtained good results in 11 patients and fair results in 3 patients using Ratliff clinical evaluation. According to Lloyd-Roberts radiographic rating, 2 hips were rated good and 12 were rated fair. Their radiological Stulberg evaluation however, showed 7 in class II, 6 in class III and 1 in class IV hips. The epiphyseal extrusion was improved to average 12% in 13 out of 14 cases at followup. Sarassa *et al*. evaluated 10 patients within age group of 8–13 years with severe LCPD (Catterall III and IV and Herring class B and class C) using double osteotomy surgical procedure.[53] With an average followup of 46.5 months, they reported 4 good, 5 fair and 1 poor in accordance with the Ratliff classification and Lloyd Roberts radiological results. There were 5 good and 5 fair according to Mose index radiological results. Based on the Stulberg classification, there was 1 patient in class I, 5 in class II, 3 in class III and 1 in class IV. The epiphyseal extrusion has improved after the surgical procedure to 12.1%. Eamsobhana and Kaewpornsawan have reported 20 cases of severe LCPD treated by combined osteotomy procedure.[54] With an average followup of 49 months, the postoperative clinical results were 15 good, 3 fair and 2 poor in accordance with Ratliff classification. According to Mose scale, 8 patients had good results, 9 had fair results and 3 had poor results. According to the Lloyd-Roberts classification 8 patients had good results, 9 had fair results and 3 had poor results. Based on the Stulberg classification, there were 10 patients in class II, 9 in class III and 1 in class V.

In agreement with the criteria published by these authors, in the present study children with severe hip disease assessed by Catterall (III, IV) and LP groups (B, B/C, C) were included for combined osteotomy surgical correction procedure. All patients in this case series had lateral extrusion and they responded combined osteotomy surgical procedure fairly well. Patients with hinge abduction were not included in this study as they need valgus osteotomy to prevent impingement.

This series showed good results in patients who are younger than 6 years of age. It showed that young age is one of the most important prognostic factors in LCPD and this fact is thought to be attributed to the amount of remaining growth and the opportunity for femoral head remodeling. Female gender in this series has poor outcome than their male counterparts as they suffer from more severe disease and may be more susceptible to complications. It has been reported that delayed skeletal maturation in LCPD is more pronounced in boys, giving them a greater potential for remodeling.[28]

Containment treatment in this series gave clinical results good (n = 12) and fair (n = 9) in accordance with the Ratliff classification, good (n = 8) and fair (n = 13) results according to the Mose radiological criteria. Stulberg *et al*. by reviewing radiographs taken at skeletal maturity in patients with LCPD developed a classification system that could predict the incidence of osteoarthritis before 50 years of age.[6] In the present study, these early results could indicate a long term improvement in the prognosis of late presentation LCPD and a decrease in the probability to develop osteoarthritis in adulthood as 10 patients were rated modified Stulberg (Neyt *et al*.) group A (Stulberg I or II), which implies good prognosis and low incidence of osteoarthritis. Eleven patients were group B (Stulberg III) that implies fair prognosis and late presentation osteoarthritis and two patients were rated group C (Stulberg IV or V). The results of this study compare favorably with results reported in other published studies of same operative treatment in severe LCPD [Table 5].

With the early results obtained in the present study, the author of this paper believes that it is justifiable to perform a combined osteotomy with the aim of trying to improve the long term prognosis in cases with extensive femoral head involvement in children with severe form of LCPD. It provides an alternative surgical option in patients with severe LCPD who are associated with lateral extrusion, deformity and collapse of the femoral head are known to have a poor prognosis in the long run.

The limitation of this study is that all the patients were not followed up to skeletal maturity. The outcome depends on the age, gender, stage of the disease, epiphyseal extrusion and head-at-risk signs. Clubbing all the results across these variables is bound to include confounding issues. The presence of residual extrusion, trochanteric overgrowth and avascular necrosis of femoral capital epiphysis should be recognized early and treated appropriately to ensure optimum results.

Conclusion

Containment surgery gives favorable results and surgical intervention should be performed as soon as the patient is diagnosed with severe LCPD. This is a safe and effective procedure that can provide excellent femoral head containment without increasing hip stiffness or significant limb shortening. This method of containment can result in significant spherical remodeling of a previously deformed femoral head. The potential disadvantages of the combined osteotomy are that it is technically more difficult procedure than either femoral or innominate procedures alone, longer operative time and more blood loss.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Table 5: Details of previous series and comparison of results

Author	Number of hips	Mean age at surgery (years + month)	Type of surgery	Mean followup (years + month)	Results					
					Clinical			Radiological		
					Good	Fair	Poor	Good	Fair	Poor
Olney and Asher[50]	9	8+1	Combined	4+8	7	2	0	4	4	1
Chakirgil[51]	26	6+10	Combined	3+5	61.5%	-	-	61.5%	-	-
Crutcher and Staheli[52]	14	7+3	Combined	8+0	11	3	0	7	6	1
Sarassa *et al*.[53]	10	9+2	Combined	3+10.5	4	5	1	6	3	1
Eamsobhana and Kaewpornsawan[54]	20	7+7	Combined	4+1	15	3	2	10	9	1
Present series	23	6+6	Combined	5+8.5	12	9	2	10	11	2

Conflicts of interest

There are no conflicts of interest.

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